Science and the politics of sustainability: an analysis of four research-council funded bioenergy projects.

Submitted by Thomas William Richardson, to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Politics

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

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Abstract

This thesis provides a detailed exploration of the way that four large research-council-funded bioenergy projects have engaged with the politics of bioenergy sustainability. Given the contested nature of sustainable development and the nature of the science in question, this thesis takes a discourse analysis approach to critically examine the functioning of these projects in the context of the wider politics surrounding the issue of bioenergy sustainability. Drawing on in depth interviews and a wide-ranging analysis of the literature, this thesis presents a number of findings. While used in strategically ambiguous ways, under the dominant ecologically modernising discourse governing bioenergy, sustainability is primarily constructed as synonymous with least-cost decarbonisation. Policy support for bioenergy is built around a technologically optimistic storyline, underpinned by a number of assumptions, including a linear view of scientific policy making. This dominant discourse around bioenergy has been challenged in two main ways. The first of these has rejected the over emphasis on carbon balances and economics as the primary metrics against which bioenergy sustainability should be measured. Decarbonising our energy supply has become increasingly dislocated from its underlying (disputed) ethical and moral rationales. As such it has seemingly become an end in its own right. The second challenge is more subtle and involves a rejection of the framing of bioenergy sustainability as a scientific and technical problem.

Although reproducing a more administrative type discourse, the science initiatives explored in this thesis appear to reinforce much of the dominant discourse. As well as reflecting certain practices associated with the governments focus on scientific policy making, a lack of reflexivity to the strategic aims of energy policy within science also reflects a strong positivism and shared reliance on the perceived linearity of scientific policy making. It is argued that if science is to be liberated to fully respond to the challenges of sustainability, scientists need to be more reflexive as to the (political) role of science in modern environmental controversies, questioning both what their impacts might be and whose interests they are serving.

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Chapter 1: Introduction

Bioenergy has been promoted by the UK Government as a sustainable technology in the fight against climate change (DTI, 2003; 2006a; 2007; DEFRA, 2007; HM Government, 2009a). However, like genetic modification (e.g. Wynne and Mayer, 1993; Mayer, 2003; Horlick-Jones *et al.*, 2006), nuclear power (Irwin and Wynne 1996), and nanotechnology (Pidgeon and Rogers-Hayden, 2007) before it, it is fast becoming the site of an intense political struggle. This thesis is concerned with exploring the way that research-council funded science has engaged with the politics of bioenergy sustainability. Before introducing the specific objectives of this thesis, this chapter will first introduce bioenergy in the context of UK energy policy, and also introduce some current thinking over the role of science in sustainable development.

1.1 Bioenergy

Although bioenergy has been driven forward as a 'solution' (whether to climate change, the rural economy or security issues), the diversity of production and consumption methods as well as the proposed scale of its use, has raised many questions regarding its potential social and environmental impacts (e.g. FAO, 2007; 2008a; Greenpeace, 2007; Oxfam, 2008). The last few years has witnessed a growing public concern over the 'sustainability' of the sector. However, like the debates that developed around genetic modification (GM), nuclear power, and bovine spongiform encephalopathy (BSE) this is not a debate purely about facts, solvable by the simple provision of more information or better discussion. Instead, it is a debate that extends deep into the public imagination, touching on and questioning the fundamental values of our society and the very direction of modernity. Within the bioenergy debate, knowledges, both scientific and non-scientific are contested and there is discursive struggle over both the framing of the issues and the legitimisation of knowledge and expertise.

1.1.1 Bioenergy technology

Biomass can be converted to heat and energy by a variety of technologies, from small-scale heat-only combustion plants to large electrical-only and combined heat-and-power (CHP) plants. It can be blended in varying quantities with other fuels, such as coal, and co-fired in traditional power stations, or digested in anaerobic digestion facilities (AD) to produce biogas for combustion. It can also be refined into liquid biofuels (primarily bioethanol and biodiesels but also others such as biobutanol). Bioethanol can be produced from the fermentation of sugar or starch containing foodstuffs such as grain or sugar cane. It can also be produced by 'second generation technologies' that employ chemicals or enzymes to break down cellulose, prior to fermentation to alcohol. Biodiesel encompasses a range of oil based fuels and can also be produced by a number of routes. A variety of oils such as palm, soy, coconut, rapeseed, sunflower and animal fats can be converted to a diesel like substance through trans-esterfication. Wood and plant residues can also be upgraded through a more complex process known as Fisher-Tropsch (Inderwildi *et al.*, 2008).

Theoretically any biological material can be used to produce bioenergy, and secondary products, wastes and residues can also be utilised for combustion, digestion and refining. Thus, straw, wood waste from forestry and chicken litter are currently primarily used in bioelectricity and CHP plants; used-oils can be converted to biodiesel, and slurry and food wastes are routinely utilised in anaerobic digestion (AD). The scope for bioenergy is vast and particular feedstock is not restricted to particular processing or end use but can instead be used in a number of different ways and for different processes. In this respect, rather than a number of discrete bioenergy systems composed of their particular feedstock, processing and application, the potential for bioenergy is much more flexible.

A wide range of crops can be grown as feedstock for either direct combustion or refining into liquid fuels. Presently the majority of bioethanol is produced from traditional crops such as maize and sugar cane (Worldwatch Institute, 2007) in the USA and Brazil respectively. The primary oil crops grown for biodiesel are

palm (grown extensively in SE Asia) and soya (S. America), although in the UK and Europe, oilseed rape is also important. Although food crops such maize and sugar cane are currently the primary feedstocks for conversion to biofuel, it is assumed that second generation processes utilising cellulosic and lignin rich feedstocks such as willow (*Salix* spp.) or Miscanthus (*Miscanthus sp.*), will be commercially viable by 2015 (Earth Policy Institute, 2006). While the terminology around bioenergy can be confusing, and is often used in contradictory ways, box 1 makes some definitions used in this thesis.

Bioenergy terms

Bioenergy: energy derived from biomass.

Biofuels: energy carrier derived from biomass.

Biogas: a methane rich gas derived from anaerobic digestion of biomass (sewage sludge gas, landfill gas, other wastes etc.).

First generation biofuels: biofuels produced from converting sugar, starch and oils into liquid fuels.

Second generation biofuels: biofuels derived from lignocellulosic material (e.g. agricultural wastes and residues, woody crops and grasses).

Liquid biofuels: bioethanol, biodiesel, biodimethylether, synthetic diesel, pyrolisis oil.

Modern bioenergy: All biofuels and bioelecrity and heat generated using efficient conversion technologies.

Biomass: covers solid non-fossil material of biological origin which may be used as fuel for bioenergy production (wood, conventional crops, other solid wastes such as straw, rice husks, nut shells, poultry litter, biodegradable fraction of municipal solid waste).

Traditional bioenergy: fuelwood and charcoal which can only deliver heat.

Box 1. Definitions of bioenergy used in this thesis

Other sources of bioenergy such as cultivated algae are also being researched as potential feedstocks. Algae potentially has the advantage of being extremely high yielding and also potentially avoiding many of the land use issues associated with terrestrial feedstock production. Currently however there are no commercial scale examples of algae bioenergy, and as such it is not considered to represent a viable alternative to plant derived bioenergy in the short to medium term (FAO, 2009a).

The potential uses for and the flexibility in transforming various biomass sources into useful energy is increasing as new breakthroughs in science and technology realise new ways to produce and process biological material. The climax of this versatility is envisioned in the concept of the biorefinery; a bioenergy system capable of refining and processing a wide variety of feedstock in to an even wider range of bioenergy and biomaterials. This flexibility has led some to the prediction of a future 'bioeconomy' (UKERC, 2006) to replace the current oil based one. The development of bioenergy however will depend to a large extent on the policy context within which it is developed.

1.1.2 Energy Policy

Bioenergy has been promoted to help meet a number of policy objectives, and it is expected that it will make a significant contribution towards the UK's ambitious renewable energy targets (DTI, 2003; DEFRA, 2007; HM Government 2009b). Much of the impetus for RE development in the UK has been stimulated by policy set at the EU level, and as such any developments in the UK have to be considered within a European context. On 26th March 2009 the EU adopted the Renewable Energy Directive (RED) (2009/28/EC), first proposed by the Commission back in January 2008 (CEC, 2008a). This piece of legislation provides binding targets for the contribution of RE to EU final energy supplies for 2020. While the EU target is set at 20% by 2020, the disaggregated target for the UK is 15%. As part of this target, the directive also requires member states to supply 10% of their transport fuel from renewable sources by 2020. This legislation builds on the 2003 Biofuel Directive (2003/30EC) that

required Member States to set indicative targets for biofuels sales in 2005 (2% by energy content) and 2010 (5.75%).

The enactment of the mandatory RED targets at the European level has replaced a number of national targets, and potentially raise the amount of RE needed in the UK electricity sector to somewhere near 35% of total supply. Delivering 15% of the UK's energy demand through renewable energy technologies represents a large increase. Box 2 summarises the UK's leading scenario for how this is likely to be achieved, as set out in the 2009 Renewable Energy Strategy (HM Government, 2009b).

Scenario for achieving 15% RE supply in the UK

More than 30% of electricity generated from renewables, up from about 5.5% today**.** Much of this will be from wind power, on and offshore, but biomass, hydro and wave and tidal will also play an important role.

12% of heat generated from renewables, up from very low levels today**.** We expect this to come from a range of sources including biomass, biogas, solar and heat pump sources in homes.

10% of transport energy from renewables, up from the current level of 2.6% of road transport consumption. This will mostly be met by the supply of biofuels.

Box 2. Lead RE scenario for UK in meeting targets set out in RED (HM Government, 2009b)

As can be seen from box 2, bioenergy is expected to play a large part in contributing to the UK's renewable energy targets. UK government support for bioenergy at both the UK and EU level is reflected in the emergence of a new 'sustainable' energy policy in the UK (DTI, 2003). However, while under this

policy framework there has been strong support for biofuels for transport, attempts to translate higher level RE targets into lower level bioenergy targets for heat and electricity have not taken been up. Arguably the UK has thus witnessed a relatively slow uptake of bioenergy technologies in these sectors (Thornley and Cooper, 2008). Growth in these sectors has also primarily been through the large scale co-firing of imported biomass. This unwillingness to directly support individual technologies within the heat and electricity has been shown to reflect a particular 'paradigm' or way of thinking about the role of the market in energy policy (Mitchell, 2008).

1.2 The politics of a sustainable bioenergy

Much of the debate over bioenergy at the beginning of the decade was thus concerned with how best to stimulate the uptake of bioenergy technology, with much associated criticism of the dominant policy mechanisms. However around 2005, with the announcement of the UK's own Renewable Transport Fuel Obligation (RTFO), there emerged the first signs of a serious public debate over the sustainability of biofuels. While this debate has started slowly, it has expanded to include a wide range of political actors. Despite the very public concerns over biofuels (and now other bioenergy technologies as well), the EU and UK government has stayed committed to expansion of the sector and the pursuit of minimal criteria based standards for sustainability.

1.2.1 Environmental and social implications of bioenergy

While the utilisation of wastes is desirable from an environmental perspective, it is widely recognised that due to limited resources and high marginal costs of recovery, any large scale transformation to bioenergy in the UK and EU will involve the widespread use of dedicated energy crops, both traditional and novel (Ecofys, 2008). This is the case for both transport, and heat and electricity targets (CEC, 2005; DEFRA, 2007; HM Government, 2009a). It is also assumed that to meet the current biofuels targets, feedstock and fuel will need to be

imported in to the EU (CEC, 2005) and the UK (DTI, 2005). These land-use and trade dimension have emerged as the primary points of contention over the likely impacts and hence desirability of bioenergy. However, whether a particular bioenergy practice has a positive or negative impact will depend largely on context.

While it is expected that the impacts of bioenergy are likely to be perceived and experienced asymmetrically by people, the complexity and diffuse nature of causality associated with displacement effects means that our knowledge and power of prediction over these effects are likely to be equally uncertain and contested. Ecosystems are inherently complex, a fact often obscured by the simplicity with which environmental problems are portrayed and policy solutions prescribed. Due to this complexity, environmental issues are often characterized by high degrees of uncertainty. Not only is our understanding of ecological processes at landscape scales immature, but the likely deployment and use of bioenergy is deeply entangled with social and cultural systems, with specific practices likely to be driven largely by economic concerns. Thus as well as it being difficult to predict where, when, how and on what scale crops might be grown for energy purposes, it is also difficult to know what impact on water resources, food prices and local economics they might have.

1.2.2 Sustainable Development

While there are concerns over the social and environmental impacts of bioenergy and in particular biofuels, the political struggle over the sustainability of bioenergy represents more than just a conflict over a new technology. The struggle over bioenergy can be viewed as a much broader struggle over the definition of sustainable development and the very direction of modernity. While some environmental perspectives tend to out rightly reject the use of the sustainability concept (i.e. Naess, 1997), it has nevertheless become primary way in which modern society discusses the environment and development problem. Although substantively vague, a broad international agreement has emerged that the goals of sustainable development should be to foster a

transition toward development paths that meet human needs while preserving the earth's life support systems and alleviating hunger and poverty.

The Bruntland Commission defined sustainable development as "development that meets the needs of the present without compromising the ability of future generation to meet their own needs" (WCED, 1987, 8 and 43). In 1992, the Rio Earth Summit brought sustainable development on to the global agenda, reaffirming the ideas set out in the Bruntland report in its own action plan, 'Agenda 21' (UN, 1992). However, other radically differing interpretations draw explicitly from the sustainable development concept. Many different visions of a sustainable society and the means of resolving the 'environment and development' problem thus exist.

The literature on sustainable development is vast and critiques of the UN position, as well as alternative interpretations can be found within fields as diverse as conservation biology (i.e. Newton and Freyfogle, 2005), poststructuralism (i.e. Escobar, 1995), economics (i.e. Daly, 1996) and environmental Marxism (i.e. Foster, 2002). Sustainable development can thus be considered an "essentially contested concept" (Jacobs, 1999; Ehrenfeld, 2009), forever engendered in debate as to the meaning and the degree to which one can attain whatever is named by the concept.

1.3 Science and sustainability

Throughout human history, science and technology (S&T) has been increasingly influential in shaping both positive and negative development trends. However, although S&T is recognised as being central perpetrators of many of our current sustainability challenges, there is a widespread belief that S&T is also vital for a societal reorientation toward more sustainable development (e.g. UN, 1993; UN, 2002; HM Government, 2005). However just as there are various understandings and prescriptions for sustainable development and sustainability, so there are equally contested ideas of how

science as an institution and as a particular form of practice should re-orientate itself so as to better contribute to a more sustainable development.

Complex socio-environmental issues are increasingly characterised by a reliance on expert advice, negotiated and regulatory science, which has been called on to provide a firm basis for justifying and making political decisions credible. When faced with dilemmas in the modern era, politicians increasingly seek refuge in 'sound science'. However, in the face of a science, which is in many areas provisional, uncertain and incomplete, increased use of expert advice has paradoxically not produced more certainty. In many instances competing expert knowledge has given rise to a battle between experts and counter-experts (Jasanoff, 2004). On the back of such scientific controversy, during the past two decades, the privileged position of science as arbitrator of objective truth has been widely challenged. This challenge has systematically critiqued both the notion of science as a realm of facts, separate to that of politics, and the traditional linear view of scientific policy making.

In response to a perceived scientisation of environmental policy (e.g. Liftin, 1994; Jasanof, 2004), and a narrow focus on wealth generation, in particular there have been calls for a more accountable and legitimate science (i.e. Lubchenco, 1998; Gibbons, 1999; House of Lords Science and Technology Select Committee, 2000; Gallopin *et al.*, 2001; Kates *et al.*, 2002; ICSU, 2002; ICSU, 2005). That is, a move towards a science that is not only more focused on solving real world problems, but that is also reflexive in a consideration of whose 'problems' it is solving.

Despite the numerous calls for greater accountability and a reassessing of the role of scientific knowledge in social change, there is something of a lacuna in the literature focussing on exactly how this might translate in to practice and how such a 'transformation/transition' to a more democratic science might be assessed (Backstrand, 2004). There is also little work looking at the broad role that specific scientific institutions or programmes of research might play in the politics of sustainability issues. Thus, in the context of our current understandings of how science is practised and knowledge legitimised, what

does it mean to be accountable, democratic or legitimate? While much research in the sociology of scientific knowledge has focused on the way specific knowledge and expertise is constructed, legitimised and used, this is rarely explicitly tied to specific theories of social change (although see Jasanoff, 2004 on the co-production of knowledge). Likewise, sociology and political theory, for their part, have tended to leave science, and technology out of their analytic programmes (Jasanoff, 2004).

1.4 The aims of this thesis

As with other recent techno-science controversies, the controversy over bioenergy has resulted in a drive for a more policy relevant bioenergy science in the UK. While recognised as fundamental to the technological development of a modern bioenergy sector, publicly funded science is now also increasingly concerned with the delivery of a 'sustainable bioenergy'. Acting as our primary resource for independent research in the UK, between 2002 and 2008 Research Councils UK commissioned a number of large, strategically focused projects aimed at ensuring the sustainability of bioenergy. These are: the Sustainable Power Generation and Supply (SUPERGEN) Bioenergy project; Toward a Sustainable Energy Economy (TSEC) BIOSYS project, the Rural Economy and Land Use (RELU) Biomass project; and the bioenergy function of UK Energy Research Centre (UKERC).

Given the contested nature of sustainability and the fact that these initiatives are not designed to be regulatory, in that they are not directly involved in advising policy, this thesis takes a discourse analysis approach to explore the way that these projects have engaged in the politics of a sustainable bioenergy. Discourse analysis has exerted a growing influence on research in science and technology studies (STS) (Jasanoff, 2004). In this thesis, discourse is considered to be more than communicative exchange. Rather, discourse is imagined as a complex entity that extends into the realms of ideology, strategy, language and practice. In this conceptualisation, it is the continuous power struggles between competing discourses that create the conditions that shape

the social and physical world, and construct the individual (Sharp and Richardson 2001). Viewing discourse as the engine of social change, this thesis is based on the assumption that not only does it matter how bioenergy science contextualises its work and potentially reproduces particular understandings of bioenergy, but it also matters how this manifests in practice. The primary aim of this thesis is approached with the answering of three specific questions (Box 3). In answering the three questions raised under the aim of this thesis, this research takes a three stage approach (described in chapter 3), involving the analysis of documentary and interview evidence. This thesis draws on a specific typological framework (Dryzek, 1997) as well as a number of other analytical 'tools' for exploring the ways that scientists engage with the politics of bioenergy sustainability in their research.

Aim

To explore how research-council funded bioenergy science has engaged with the politics of a sustainable bioenergy.

Specific questions

This thesis approaches the primary aim of this thesis through answering the following questions:

1. How does UK energy policy discursively construct bioenergy, and how are these constructions challenged?

2. How have research-council funded bioenergy projects engaged with the wider discursive struggle over the sustainability of bioenergy, in terms of the constructions that they (re)produce and in the way they practice their research (in terms of content, aims and organisation)?

3. How have the discursive commitments of scientists been reproduced or constrained within the respective project?

Box 3. The aims of this thesis

Conclusion

This chapter has provided a brief introduction to the aims and rationale for this thesis. In doing so it has introduced a number of themes that will be covered in more detail in later chapters. Forwarded by the UK Government to help mitigate climate change, bioenergy has quickly become the site of intense political struggle. The debate over the 'sustainability' of bioenergy reflects the potentially serious impacts the technologies may have on both the environment and different peoples around the world. This thesis provides a detailed exploration of the way that recent research-council-funded bioenergy science in the UK has engaged with the politics of a sustainable bioenergy. Given the contested nature of sustainable development, this thesis takes a discourse analysis approach to critically examine the functioning of 4 specific UK based science projects in the context of the wider debate surrounding the issue of bioenergy sustainability.

Chapter 2: The importance of discourse

In attempting to characterise the role played by science in the current debate over the sustainability of bioenergy, this thesis concerns itself with two central questions. First, what is the controversy around the sustainability of bioenergy? And second, how has science as an institution engaged with this controversy? Given these broad objectives, what then is the most appropriate framework with which to address these questions? Being primarily concerned with political controversy and the subject of potential social change, this thesis approaches the question primarily through the lens of discourse and discourse analysis. However, being concerned with science and technology, and the political function of science, the thesis also draws on insights from science and technology studies (STS). The questions this thesis asks makes a number of assumptions. The most obvious, being that it is possible for science to engage in different ways, or to fulfil different roles in a political debate. As well as introducing the particular approach to discourse used in this thesis and its amenability to the study of science, this chapter also clarifies the way that the thesis understands 'science'. The chapter is divided into two sections. The first section goes into some detail explaining what this thesis means when it uses the word 'discourse'. This section also introduces a number of general concepts that are used in this thesis to help analyse discourse. The second section discusses relevant insights from science and technology studies (STS) and their use in this thesis. This section also takes a look at scientific discourses and the use of discourse analysis in science.

2.1 Discourse and environmental politics

Environmental and socio-environmental issues are complex, both because ecosystems are complex and our knowledge of them is limited, and because human societies are also complex. In addition, these issues are also often overlapping. For example, the problems of climate change and agricultural expansion, while different, are nevertheless inherently linked. While there are many (more institutional or philosophical) approaches to the study of

environmental politics, discourse analysis has become increasingly important in this field. While environmental arguments may seem factual and scientific, they are also suggestive, meaningful and atmospheric. To this end, underlying hard policy intervention there is always the creating, thickening or discarding of meanings. These meanings affect the outcomes, laws and institutions and indeed become the context in which the environment can be discussed (Myerson and Rydin 1996).

Meanings do not just materialise, but enter politics through particular sets of mutually constructed rules and norms that give coherence to social life. Given the changes in practice (be it the creation of institutions or the enactment of laws etc.) that discussions about the environment can lead to, whether the environment is discussed in terms of spaceship-ness of the Earth, the green-house-gas-ness of climate change, or the disease-ness of pollution, matters (Myerson and Rydin 1996). To this end, it is widely recognised that in environmental politics, language matters, and that the way we construct, interpret, discuss and analyse environmental problems has all kinds of consequences. Likewise, concepts such as sustainable development or the precautionary principle, are not and cannot simply be imposed in a top down way, but are continuously contested in a struggle about their meaning, interpretation and implementation (Richardson and Sharp 2001; Hajer and Versteeg 2005).

2.1.1 So what is discourse?

The term ‘discourse’ is a widely used and contested concept, and while in everyday life the concept is regularly used as interchangeable with words such as ‘discussion’ or ‘talk’, within academia, various disciplines within the social sciences and humanities have developed more nuanced and often very different definitions of the term (Hastings, 1999, 2000). However, throughout these disciplines, discourse generally refers to ‘language in use’ (Weatherell, 2001). Discourse analysis (DA) and discourse studies can be then used to describe a number of approaches to analysing written, spoken, signed language

use or any significant semiotic event. However there are conceptions of discourse that aim to move beyond textually orientated approaches, to embrace other aspects of social change that lie beyond the texts that are produced along the way.

Within critical theory, sociology and philosophy, a focus on discourse is often also associated with a social constructionist[1] perspective and an interest in the role discourse plays in social change. As such, discourse analysts in disciplines such as urban geography, planning studies and environmental politics argue that assuming policy language to be a neutral medium, through which ideas and an objective world can be represented and discussed, overlooks the extent to which policy and its language is contingent on social constructions of reality. Thus, the way that policy decisions are enunciated, is seen as the outcome of power relations, ideological contestations and political conflict, and also as a source of such influences (Ockwell and Rydin, 2006). To this effect, it is advocated that exploring and laying bare the way language is used in such contexts is critical to revealing aspects of social and political processes that were previously obfuscate.

Even within the disciplines mentioned above, there is much variation in the conceptions of discourse and there are a large number of alternate ideas as to how exactly discourse might influence the policy process (Ockwell and Rydin, 2001). Many of these understandings of discourse are still primarily text based. That is discourse is conceived as what is said or written, or the sum of communicative action (e.g. see Hastings 1999). Fairclough (2003) contrasts what he refers to as textually orientated discourse analysis, which focuses primarily on spoken and written instances of discourse, with approaches to discourse analysis that have a more social theoretical orientation.

[1] Social constructionism is a body of theory that in addition to emphasising the socially created nature of social life, can also be associated with constructionism in the epistemological sense, as opposed to realism

2.1.2 The structure/agency debate

Different conceptualisations of discourse and therefore approaches to discourse analysis hinge largely on two related issues. The first of these concerns the assumed relative roles of structure and agency in social change. Agency in this context refers to the assumed capacity for individuals to act independently and of their own 'free will'. Structure on the other hand refers to the constraints imposed on individual action by wider sociological patterning and constructs. While some positions assume the capacity of individual "agents" to construct and reconstruct their worlds at will, others stress the importance of social structures in shaping and fundamentally constraining human agency. Within theories of structuralism and some forms of functionalism, the perceived agency of individuals is mostly explained by the operation of this structure. This debate over the primacy of structure or agency also relates to an issue at the heart of contemporary sociological theory: the question of social ontology or to what degree reality is social constructed (see section below).

While people still work with theories either emphasising the relative importance of structure or agency, increasingly social theorists (Bourdieu, 1977, 1990; Foucault, 1980), have attempted to find a point of balance between the two previous positions. Taking a more nuanced view of the debate, and rejecting purely structuralist explanations (e.g. Levi-strauss, 1970), the post-structuralist movement conceptualised structure and agency as complementary forces - structure influences human behavior, and humans are capable of changing the social structures they inhabit. Structuration (Giddens 1998) is one prominent example of this view. Michael Foucault's work has been particularly pivotal in the development of the study of discourse (Ockwell and Rydin, 2006). Foucault developed the idea that knowledge was constructed as discourse and represents the capillary flow of power within society (Foucault, 1980; Rydin 1999). From this perspective, different discourses (or different systems of meaning) compete for influence in society. Consequentially, structural shifts in society can be viewed as shifts in the relative influence of different discourses, which are in a continuing struggle for discursive hegemony. Rather than viewing discourse as text or communication distinct from the norms and institutions

which facilitate its practice, discourse is instead viewed as constitutive of these very structures. In this interpretation, power relations and their relationship with knowledge become central. Discourse here can be considered to constitute an entity of repeated linguistic articulation, physical practices and power-rationality relations. Similarly, as opposed to more positivist interpretations, discourse is not to be seen as a medium through which individuals can manipulate the world, but instead as itself part of reality and constituting the discoursing subject. Despite the differences between text based and more encompassing conceptions of discourse, all such 'users of discourse' emphasise the importance and complexity of communication in achieving social change. Another similarity between the different traditions of discourse-use concerns their objective in exposing inequalities of power as a means for achieving social change.

2.2 The use of Discourse in this thesis

Confounding the variation in uses of the concept of discourse discussed above, it has also been noted by others that researchers use many different notions of discourse, often without a clear definition of what is meant by the term (Sharp and Richardson, 2001). It is thus deemed important to define how this study conceptualises the term and goes about its analysis. While Foucault's work has had a profound influence on many areas of research in the social sciences and humanities, a number of criticisms have been leveled at his theoretical position. Relevant here is the charge that he exaggerated the extent to which the majority of people are manipulated by power, not giving enough weight to the possibility of discursive struggle and the possibility of dominated groups opposing dominant discursive and non-discursive systems (Fairclough, 1992; Hajer 1995). Thus it is argued by some that Foucault overemphasises the role of structure over agency. Associated with this criticism, it is also claimed that Foucault also overstates the constitutive effect of discourse (Fairclough, 1992) and thus takes too much of a relativistic perspective.

Given the contested nature of the bioenergy debate, this thesis takes a dialectical approach to the structure/agency dilemma. While it is recognised that actors are able to challenge 'conventional' ways of seeing and meaning, it is also conceded that actors are often constrained by particular discursive commitments, and that these commitments are constituted in social practices. This thesis draws explicitly on the work of two authors, namely, Marteen Hajer and John Dryzek. While these authors conceptualise discourse slightly differently (taking slightly different ontological positions regarding the extent to which discourse constitutes reality), these differences are minimal. That is, while they differ slightly, they are similar enough to be theoretically compatible. Thus, while these authors both loosely draw on Foucauldian conceptions of discourse, they both explicitly put more emphasis on the role of agency in social change (in terms of the possibility for individuals to influence social change and change their 'discursive affinities') and also assume a more realist ontology (that is, recognize to some extent the materiality of reality).

In this thesis, discourse is envisaged not just a communicative exchange, but rather a shared way of comprehending the world. Embedded in language, it enables those who subscribe to it, to interpret bits of information and put them together into coherent stories and ways of understanding the world. Thus, discourse in this context can be envisioned as multiple and competing sets of ideas and metaphors embracing both text and practice. Or in the words of Marteen Hajer: "a specific ensemble of ideas, concepts, and categorizations that are produced, reproduced, and transformed in a particular set of practices through which meaning is given to physical and social realities" (Hajer 1995). Resting on assumptions, judgements and contentions, discourses construct meanings and relationships, helping to define common sense and legitimate knowledge. In this conceptualisation, the continuous power struggles between competing discourses create the conditions that shape the social and physical world, and construct the individual (Sharp and Richardson 2001).

2.2.1 A more important role for human agency

While many structuralist (and post-structuralist) approaches are best suited to situations where a particular knowledge claim is dominant, indeed, so dominant that it is unquestioned and unchallenged, Hajer (e.g. Hajer, 1995) and Dryzek (e.g. Dryzek, 1997) are concerned primarily with exploring discursive conflicts. In doing this they foreground issues of problem construction in policy processes and wider political debates. For example, in his 'cultural politics', while taking the concept of power/knowledge, Hajer (Hajer, 1995; Hajer and Wagenaar 2003) focuses on the role of argumentation (Billig, 1987) in social change. Thus he specifically addresses the 'gap' in Foucauldian theory as to how individuals are actively involved in the prevalence of certain discursive constructions. Hajer (1995) develops the notion of storylines and discourse-coalitions (see section 2.2.2) to help explain how individuals engage in politics and contribute to the process of social change.

Despite ascribing a greater role to agency, both Dryzek and Hajer emphasise the power inherent in structured ways of seeing, and it is proposed that the routinization of cognitive commitments within a discourse gives a certain degree of permanence to discursive understandings (Hajer, 1995; Dryzek, 1997). Thus 'once having taken up a particular position as one's own, a person inevitably sees the world from the vantage point of that position (Davies and Harre, 1990). As such, the way that a discourse views the world is not always easily comprehendible to those who subscribe to other discourses. Discourse on the one hand is shaped and constrained by social structure in the widest sense and at all levels (by class, institutions, norms etc.), and on the other hand constitutes these phenomena. Discourse contributes to the constitution of all of those dimensions of social structure which directly or indirectly shape or constrain it. Discourse is thus seen as a practice of not just representing the world, but of signifying the world, constituting and constructing the world in meaning. Discourse conditions the way we define, interpret and address environmental affairs (Dryzek, 1997). However, just because something is socially interpreted or constructed does not mean it is unreal, and this is something that is emphasised by both of the authors above. For example, just because pollution

is interpreted in different ways, does not lead to the conclusion that pollution does not cause illness, just that people can make very different things of these phenomena. This is why we have environmental politics and politics in general.

2.2.2 Meta-level concepts: Storylines and discourse coalitions

A central concept within Hajer's work on acid rain was the notion of 'story-lines' (Hajer, 1995). The underlying assumption is that instead of drawing upon a comprehensive discursive system, actors evoke discourses through use of recognizable story-lines. These storylines can be envisaged as narratives on social reality through which elements from many different domains are combined and that provide actors with a set of symbolic references that suggest a common understanding (Hajer, 1995). In this way, storylines act to facilitate the discursive complexity of a problem, give ritualistic permanence to a debate and allow actors to expand their own understanding and discursive competence of the phenomenon beyond their own discourse of expertise or experience. A storyline provides the politician, scientist or environmentalist reference to illustrate where their work fits into the 'bigger picture' (Hajer and Wagenaar 2003).

Storylines allow the overcoming of fragmentation and the achievement of discursive closure, and by uttering specific elements, for example 'rain-forest', one can re-invoke the story-line as a whole. Actors thus may not necessarily understand the detail of the argument; instead, argumentative discourse analysis holds that the power of storylines is essentially based on the idea that it sounds right. In this way, discursive formats, rather than actors and their intentions are seen as primarily influencing the construction of problems. Whether something sounds right being based on the plausibility of the argument, the trust held by others in the author and practice in which it is produced and the acceptability of the storyline for their own discursive identity (Hajer, 1995). Storylines not only help construct a problem, but they also play an important role in the creation of social order, in which actors are positioned, and specific ideas of blame and responsibility, urgency and responsible

behavior are attributed. As well as providing the narrative within which a specific actor can understand their contribution to knowledge or localize their preferences, storylines can also be seen to influence actors in their own production of knowledge (Grey, 1990; Hajer, 1995).

2.2.3 Storylines and keywords; the case of sustainable development

The current public and scientific debate over bioenergy and in particular biofuels displays deep ideological division between discoursing participants, and it is strikingly obvious that what a sustainable bioenergy future might entail is something that is far from consensual. Despite this, individuals and organizations with contrasting views frame bioenergy and biofuels in the context of sustainability and sustainable development. Thus while Hajer (1995) described 'sustainable development' as a storyline reflecting a purely ecological modernistic discourse, it is clear that the concept is employed by individuals ascribing to a much wider range of discourse positions (e.g. Jacobs, 1991; Dryzek, 1997; Becker *et al.,* 1999). This ambiguous use of 'sustainability' as a framing concept has been explored by others. Letich and Davenport, (2007) identify sustainability as a 'keyword', in the development of GM policy in New Zealand. That is a word that is salient to the issues that are central to that particular discourse but also for which there is potential multiple meanings (Williams, 1983). In their study of the inter-textual relationship of five New Zealand Genetic Modification (GM) policy documents, they identified the important role that the term 'sustainability' played in facilitating the coherent presentation of a distinctly changed message. Thus, sustainability in this instance was identified as providing an important enabling function, and was actively used in a strategically ambiguous way to hide a multitude of different and often conflicting interests and ideologies.

According to Eisenberg (1984), there are many situations in which ambiguous communication can be more helpful than clear communication, particularly during periods of rapid change and uncertainty. He used the term 'strategic ambiguity' to describe instances in which language was intentionally deployed

in ambiguous ways in order to achieve organizational goals. Strategic ambiguity can thus be understood as a form of discourse strategy. Strategic ambiguity can promote 'unified diversity' by supporting multiple viewpoints and fostering agreement on abstractions without limiting specific interpretations (Eisenberg and Goodall, 1997). It allows divergent interpretations to exist and enables diverse groups to pursue what may be conflicting goals. Strategic ambiguity can thus serve an enabling function within discourse by allowing divergent objectives to coexist and ideologically diverse groups to, if not work together, then at least work in parallel. While the concept of keywords can be considered in some ways to be analogous to the previously described story-lines of Hajer (1995), the strategically ambiguous use of keywords however, highlights the agency of certain actors in a debate, suggesting that while this kind of storyline can be actively used to provide coherence to a multitude of interests, it can also be actively used as a discursive strategy to metaphorically silence interests within a totalising discourse. Thus it highlights very clearly the power of the ambiguous use of discourse as text.

2.2.4 Discourse coalitions

The significance of the story-line idea lies in Hajer's assertion that its widespread adoption results in the formation of 'discourse coalitions', and that these are often the primary units of interest in a debate. Discourse coalitions differ from traditional political coalitions or alliances, in that storylines not interests form the basis of the coalition, and where storylines potentially change the previous understanding of what the actors interests are. These actors may not necessarily have ever met and may apply different meanings to a storyline, but in the assumed struggle for discursive hegemony within the policy-making process, storylines act as the 'discursive cement' that keeps the discourse coalition together through the production of 'discursive affinities' (Sharp and Richardson, 2001). The concept of discourse coalitions therefore suggests searching for politics in new locations and looking for the activities of the actors that produce storylines, such as scientists or journalists, and also the practices within which this takes place (e.g. looking at the activity of specific organizations

in bringing together previously independently operating academics or policy-makers (Hajer, 1995).

Discourse coalitions and storylines are middle-range concepts that can show how discursive orders are maintained or transformed. An important assumption in discourse-coalition approach is that the political power of a text is not derived from it's consistency, but from its multi-interpretability (Hajer, 1995). That is, storylines are ambiguous and it is this ambiguity that allows a variety of actors to subscribe to them. The concepts of story-lines and discourse coalitions highlights argumentative interaction as a key moment in discourse formation and hence social change, and in this sense research should be aimed at exploring the practices through which actors seek to persuade others to see reality in the terms of the discoursing subject. To do this it is important to consider not just the words within that discourse, but also consider the positions which are being criticized.

2.3 Science and discourse

The primary aim of this thesis is to analyse the way that bioenergy science engages with the politics of a sustainable bioenergy. In doing so it draws on research carried out under the banner of science and technology studies (STS). As well as drawing on specific concepts developed within STS, the particular use of discourse (envisioned as representing a dialectical relationship between structure and agency, as outlined in the section above), is very much shaped by research carried out in STS. Science and Technology Studies (STS) is an interdisciplinary field aiming to create an understanding of the origins, dynamics and consequences of science and technology. While stemming from academic enquiry, STS is not confined to academia. Rather there are strong normative ideals (such as justice and democracy) underpinning much of the field, and STS finds itself increasingly engaging non-academics in striving toward a more equal and free society (Hackett *et al.*, 2007). Reflecting the broad range of 'disciplines' that have been drawn into the field of STS, the field does not have a set methodological approach, but rather displays a diversity of approaches to the

study science and technology in its social context. It is however, on a systematic level guided by comprehensive research interests in general aspects of sociological theory founded in the constructivist tradition. Topics such as the changing practices of knowledge production, connections between S&T and other social institutions, issues of power, democracy and governance, are all approached with theoretical eclecticism. This section introduces some broad trends in modern science (theses are also explored further later on in the thesis), concepts from STS applicable to this thesis, as well as the use of discourse analysis in STS. Taking a broad discourse-analysis approach to explore the role of science in the debate over the sustainability of bioenergy, this thesis does not look for explanation in the social construction of science (or certain facts), but rather in the political selection of and contextualisation of meaningful knowledge and the broader effects of scientization. As such it interested in the broader political role of science as a social institution, rather than science as method.

While the thesis uses a discourse analysis approach, given its focus on science, it also draws on insights from STS. While STS research into the relationship between science and policy often takes an institutional approach, the tools of discourse analysis are becoming increasingly utilised. Likewise, there is a burgeoning literature utilising discourse analysis to examine the role of scientific communication (Kerr *et al*., 1997; Calsamiglia, 2003; Ainsworth and Hardy, 2004 Motion and Doolin, 2007). As well as drawing on work from STS concerning changes in science policy practices and their underpinning rationalities/discourses (e.g. Strirling, 2006), research into 'boundary work' (e.g. Gieryn, 1983) by scientists also helped shape the particular conception of discourse used in this thesis.

Scientific discourses are meaning creation systems that emerge from the science domain to constitute concepts, objects, and subjects within a science frame or mode of representing the world (Foucault 1979). However, scientific discourses do not function in isolation. Instead, through a process referred to as interdiscursivity, they draw upon, interrelate, compete and struggle with other discourses in order to both represent and also constitute science-orientated

knowledge (Motion and Doolin, 2007). Given that each instance of popular science communication is exposed to many tensions and conflicts of interest (Calsamiglia, 2003), scientific discourse is just as amenable to deconstruction through discourse analysis as any other discourse genre.

As well as drawing on and being shaped by previous research into scientific rhetoric, this thesis also explicitly draws on STS research into science policy. While it could be argued that there is, still a hegemonic belief in the objectivity of science as arbitrator of truth in environmental and social conflicts, as evident in the STS literature there are also a number of discursive challenges to this position. These discourses are also embodied in particular practices that challenge the very way that scientific knowledge is currently produced. These practices and their discursive nature are discussed further in 2.3.4.

2.3.1 Science and the environment

Complex socio-environmental issues are increasingly characterised by a reliance on expert advice, negotiated and regulatory science, which has been called on to provide a firm basis for justifying and making political decisions credible. When faced with dilemmas in the modern era, politicians increasingly seek refuge in ‘sound science’. Science has thus been increasingly drawn into policy making, as ‘experts’ make economic, social and environmental decisions to provide policy makers with options. This is leading increasingly to a situation where decision-making is removed from democratic politics and deferred to a more opaque technocratic mode (Pimbert and Wakeford, 2001). The policy cultures that lie behind the way in which political decisions are made have tended to grant credibility to opinion only when framed in scientific language (Wynne and Mayer, 1993), and this has led to what many regard as an increasing ‘scientization’ of environmental policy and environmental discourse (e.g. Liftin, 1994; Jasanof, 2004).

The traditional idea of a linear relationship between science and policy, where scientific knowledge represents a rational and objective basis for decision-making rests upon the premise that ‘sound science’ will provide ‘objective’ facts,

from which rational policy can be deciphered. The linear model thus rests upon a realist epistemology, in which science, either through unbiased observation or universal reason, obtains objective and true representations of reality (Liftin, 1994). However, in the face of a science, which is in many areas provisional, uncertain and incomplete, increased use of expert advice has paradoxically not produced more certainty. In many instances competing expert knowledge has given rise to a battle between experts and counter-experts. Corporate science has contested environmental advocacy science and vice-versa (Jasanoff, 1990). This politicisation of scientific knowledge has arguably led to an erosion of the authority and legitimacy of science (Demos, 2004; House of Lords Select Committee on Science and Technology, 2000).

2.3.2 The social construction of science

On the back of such scientific controversy, during the past two decades, the privileged position of science as arbitrator of objective truth has been widely challenged. This challenge has systematically critiqued both the notion of science as a realm of facts, separate to that of politics, and the traditional linear view of scientific policy making. The idea that science is influenced by social factors gained prominence with the work of Thomas Kuhn (1970) and has since this time been a constant challenge to the dominant positivist conception of scientific knowledge. Research into the sociology of scientific knowledge during the 1970s and 1980s claimed scientific knowledge to be underdetermined by natural evidence and logical decision rules, and scientific observation and experiment to be underdetermined by prevailing theory (e.g. Latour and Woolgar, 1979, Collins 1985). It has also shown scientific knowledge to be variously rooted in local (i.e. laboratory) practices, with claims to universality resting on successful discursive linkages being made between disparate local practices (Latour, 1987; Pickering, 1992). It is asserted that while these properties lead to the unavoidable embodiment of assumptions and commitments directly or indirectly about the human and cultural in the constitution of scientific knowledge (Wynne, 1992), established concepts of ‘good science’, which lend politically privileged authority to particular scientific

sub-cultures and exclude others, are not to be naturally given, but rather culturally validated. Whereas as a 'normal' conception of science might portray science as an advisor of policy makers, more recent understandings of this interaction see the knowledge creation system and the decision-making process as highly interrelated and intermingled (Gibbons *et al.* 1995; Jasanoff, 2004). In this view, science plays a key role as a social actor and creator of reality in ways beyond the traditional conception of the policy making process. However, despite 20 years of work exploring the social dimensions of science, the notion that science is a source of verifiable facts and theories about reality, and can and should settle political disputes and guide action remains a central operating principle in modern-day policy making (Sarawitz, 2004).

2.3.3 Changing discourses

Partly in response to the narrow focus on wealth generation, and the fact that research is increasingly conducted within partnerships comprising the public and private sectors, there have been calls for research decision-making and agenda setting to become more transparent and democratically accountable (i.e. Lubchenco, 1998; Gibbons, 1999; House of Lords Science and Technology Select Committee, 2000; Gallopin *et al.*, 2001; Kates *et al.*, 2002; ICSU, 2002; ICSU, 2005). Citizen science (Irwin 1995), civic science (Lee, 1993), appropriate science (Wynne and Mayer, 1993) and democratic science (Brown, 1998) are all catchwords that signify the ascendancy of participatory paradigm in science policy.

Underpinned by research carried out into the social construction of science, the rise of the participatory paradigm has been largely driven by a perceived 'legitimacy crisis' in modern science (Backstrand, 2004), embodied by a number of high profile science-policy issues around GM foods, BSE and foot and mouth. Calls to 'democratise' science have resultantly been particularly strong in the food and agricultural fields (Food Ethics Council, 2004), where a technology-driven model of production has proved deepening public opposition and consumer mistrust for its ethical, health and environmental impacts (Demos,

2004). Another driver of a more participatory and interactive science has been the emergence of 'big planetary science' enabled by the innovations in global environmental modelling and the accompanying international coordination and standardisation of scientific assessment (Jasanoff and Wynne, 1998). Even though the modelling activities are concentrated in a few laboratories in the northern hemisphere, the emerging global environmental change science has been represented as global and universal knowledge. This top-down model of environmental problem solving grants power to networks of scientific experts and bureaucrats in environmental science, raising increasing concern of scientisation from those working with issues of social and environmental justice. In the words of Alan Irwin:

> *Science emerges as the form of understanding which has created environmental destruction. In late modernity, the inherent limitations of science become increasingly visible. For most citizens, science has become an obstacle to the expression of concerns. Typically, at least for Beck, science is used to silence concerns about the world in which we live rather than to enable and empower those concerns (Irwin 1995: 46)*

In 2000, a House of Lords report recommend that direct dialogue with the public should move from being an “optional add-on to science-based policy-making and to the activities of research organisations and learned institutions, and should become a normal and integral part of the process” (House of Lords Select Committee on Science and Technology, 2000). These comments are reflected in the government’s new ten-year strategy for science and innovation, which includes a commitment “to enable [public] debate to take place ‘upstream’ in the scientific and technological development process” (HM Treasury, *et al.*, 2004). Consequently, ‘Science and Governance’ is currently being given special prominence as a legitimacy problem for government.

2.3.4 Discourses of participation; a role for practice

While this thesis uses a broad environmental discourses typology (see chapter 3) to characterise the debate over the sustainability of bioenergy, in examining the role of science it is important to recognise the existence of different discourses within science, about science. While current thought on the appropriate role of science in sustainable development widely accepts the need for a more salient and legitimate science (e.g. Kates *et al.*, 2001), the perceived degree to which these ideals require changing the operation of tradition modes of scientific practice (in the form of increased interdisciplinarity or democratisation) is contested. This conflict is dependant particularly on underlying perceptions of the nature of expertise and the degree to which one perceives scientific knowledge to be connected to asymmetries of power in modern societies

While, there have been many different calls for a more participatory science, the extent to which participation is desired and the form it takes depends on both ones perception of the extent to which science is amenable to democratisation and the extent to which one sees science as inherently political. These underlying assumptions can be seen as shaping the rationale/discourses for this participation. There are three broad discourses that can be identified in the drive for a more participatory science (Fiorino, 1989; Stirling, 2004). These different rationales/ discourses can be seen as fundamentally divided by their concern for, and conceptualisations of power. They are discussed below.

1. Participatory science as instrumental in restoring public trust in science

As previously mentioned, historically one of the major drivers for a more interactive science has been a growing public mistrust of science. Citizens have increasingly felt themselves at ‘risk’ from science based technological and social developments (Irwin, 2001), and lack of confidence has been further compounded by evidence of collusion between key government scientific

experts and the commercial interests of industry (DEMOS, 2004). During the mid 1990s, this negativity was diagnosed as public irrationality and ignorance and an effort was made to create a better Public Understanding of Science (PUS) through increased communication (DEMOS, 2004). More recently, however, it is being recognised that that the real causes lie not with an insidious public ignorance, but in a growing distrust of the way knowledge is produced, governed, owned and ultimately implemented (Levidow and Marris, 2001).

A move to a more interactive and accountable science, where society is more involved, not only in issues of risk assessment at the political level, but also in engagement 'upstream' concerning questions of direction and trajectory for science and society, has the potential to help reconcile this trust, by making these motives and assumptions more transparent and decisions more accountable. An instrumental rationale is not explicitly motivated by epistemological concerns over expertise or of building public values into science, rather it is concerned with the reinvestment of public trust in science. Given that instrumental approaches are not explicitly concerned with allowing participation to fundamentally shape knowledge outcomes, these approaches might be seen as relatively supportive of incumbent interests (Stirling, 2006). The primary focus of an instrumental rational is building credibility.

2. Participatory research as necessary in addressing complex problems

Environmental problems are complex and not purely scientific in nature. They inevitably have economic, social, cultural and ethical dimensions. The impacts of our technological choices on the environment are also complex, being both diffuse and at the same time often characterised by long feedback times. This leads to an epistemological argument for a more interactive science, where the conditions of uncertainty, indeterminacy and contingency lead to a need for a more pragmatic and open-ended decision process. Politics is in this respect a substitute for certainty. In light of scientific uncertainties, ecological vulnerability and irreversibility, it is argued that the policy process should be open and transparent. The incorporation of 'other' knowledges in scientific assessment

does not rest on the assumption that lay or public knowledge is necessarily truer, better or greener (Wynne 1994), just as the increased participation called for is not driven by a general desire for democratization. However, due to the uncertainty of future environmental outcomes, possible surprises and ecological catastrophes, a multiplicity of perspectives can prevent narrowing down alternatives and make science more effective. This view holds that involvement of others in science and science policy will lead to 'better' environmental policy outcomes. A substantive rationale might also see a benefit in terms of greater social learning. As with an instrumental rational, engagement is a means to and end, rather than an end in itself. It is seen as a way of explicitly taking account of divergent values and gathering a more diverse context-specific knowledge (Stirling, 2003). Under this rationale, participation is seen as leading to substantively better outcomes.

3. Participatory research as the democratization of science

The most far-reaching notion of a participatory science is found in post-positivist policy studies and normative democratic theory. The normative core of democracy is embodied in the tenet that citizens should have participation and deliberation on issues that have bearing on their everyday life (Habermas 1975). It is arguable that the realm of science and technology constitute such an arena. In many countries, representative democracy has been heavily criticised for its inability to protect citizens' interests (Pimbert and Wakeford, 2001). Marginalised groups often do not participate effectively in representative democracies. Thus for normative rationales, participation in science is seen as helping to address this legitimacy gap. Participatory processes are advocated to enhance human rights, justice and democratic accountability. Normative rationales are concerned with countering the excise of power, however defined and participation is seen as an end in itself.

2.3.5 Participation in science for sustainability and the power of deliberation

It is obvious that these different rationales for wider participation in science potentially engender very different social practices with regard to the way science is governed (i.e. with regard to agenda setting and funding) and carried out (e.g. with regard to practices such as participation in the co-construction of knowledge).The various rationales underlying the calls for a more participatory science, particularly substantive and democratic ones, closely echo those cited for discursive or deliberative democracy (Dryzek, 2000). “Deliberative democracy” defies precise definition, but can be generally ascribed to refer to a school of political theory that assumes that genuinely representative public participation in decision-making has the potential to produce policy decisions that are more just and more rational than actually existing representative mechanisms (Baber, 2004). As such, although the current primary driver for public engagement is instrumental, there are a number of reasons why both politics and scientific endeavour should be further democratised through public engagement and deliberation.

Deliberative democracy is increasingly cited for its potential to reconcile humans and the environment in politics (e.g. Ward *et al.*, 2003), and as such, there has been a long discussion of the need for public involvement in environmental decision-making (Potschin and Haines-Young, 2006). Through deliberation, it is suggested that citizens can be endowed with both the impetus and information necessary to better grapple with the complexity of environmental problems. Being impelled to consider natural processes, and armed with improved knowledge, they are thus thought better placed to formulate positions that reflect the environmental imperative (Niemeyer, 2004). As well as transforming normative perspective, group deliberation is also thought to have an epistemic dimension, helping to overcome the problem of bounded rationality where complexity of ecological problems far outweighs the cognitive capacity of ordinary citizens (Simon, 1957).

2.3.6 The discursive construction of boundaries: a role for agency

While this thesis draws directly on the rationales/discourses set out above, work in STS on the communication strategies of scientists has also helped shape the particular conception of discourse used in this thesis. Recognizing the role of agency is important as it reflects much work that has been conducted in STS on the discursive constructions of boundaries by scientists. Scientific discourses can be distinguished from other discourse genres in a number of ways. The most important and obvious of these is the claim science makes to represent the objective nature of reality. The other aspect important here is the considerable 'expertise' associated with the production of scientific knowledge; the production of scientific knowledge is a highly technical activity, requiring many years of training. In the public sphere, scientists' authority rests on the portrayal of their exclusive expertise as objective and neutral (Gieryn, 1983; Wynne, 1992, 1996). However, for scientists working in areas of controversial science, public debate has often challenged the legitimacy and credibility of scientific endeavour (see above).

Just as the separation of science and policy is important in maintaining the authority of policy makers, in this way the separation of science from non-science and expert from lay is important in the maintenance of scientists' authority and thus resources (Gieryn, 1983). The authority and associated power of scientist to speak on certain issues is dependant on the construction of rhetorical boundaries between what counts as science and what doesn't and who counts as an expert and who doesn't. This boundary work has been shown to be a consistent feature of scientific discourse (Gieryn, 1983; 1999; Kerr *et al.*, 1997; Brown and Michael, 2001; McCann-Mortimer *et al.,* 2004; Motion and Doolin, 2007). However, it is also evident that public scientists draw and redraw the boundaries between science and society, knowledge and its application, good science and bad science and professional expertise and lay ignorance in flexible, historically changing and sometimes ambiguous ways (Gieryn, 1983; 1999).

Boundary work has been shown to be particularly evident in rhetoric disseminated by scientists in their civic roles as educators and advisors to government, at the scientist/public interface (Cooter and Pumfrey, 1994, cited in Kerr *et al.,* 1997). Scientists' involvement in guidance and education of non-academics or other publics allows them to disseminate the rhetoric of separation and objectivity, and therefore reinforce their professional power. To this end popularisation of science serves scientists (and others who derive their authority from science) as a political resource in public discourse. The dominant view establishes genuine scientific knowledge as the exclusive preserve of scientists, with policy makers and the public only able to grasp simple representations. This view of popularisation grants scientists broad authority to determine which simplifications are appropriate and which are distortions (Hilgartner, 1990, cited in Kerr *et al.,* 1997). The way scientist draw discursive boundaries as to what counts as science and what doesn't, reflects the wider social context of power relations (Kerr *et al*., 1997). In exploring the politicisation of science then it is important to investigate the ways in which scientists discuss their social roles, and to analyse what boundaries they delineate and flexibly deploy to maintain their expertise, authority and autonomy.

Conclusion

This chapter introduced the concept of discourse. In this thesis, discourse is envisaged as a particular and shared way of interpreting the world and is seen as constituting both text and practice. While discourses are actively produced by individuals, actors are not totally free and do not act within a vacuum. In this respect, discourses also have structuring capabilities as they provide the parameters within which people act and influence the world around them. Thus, while allocating a central role to discoursing subjects, a duality of structure and agency is maintained. It is possible for agents to achieve social change through discursive interaction in the context of these structures, but this inherently involves deconstructing the 'discursive hegemony' achieved by current dominant political interests.

While science plays an important role in modern day policy making, its power lies in a general assumption as to a fundamental separation of facts and values and a very linear view of scientific policy making. However, underpinned by research into the social construction of science and a number of environmental controversies, there are increasing concerns over both the 'scientization' of environmental policy and the increasing collusion of science with commercial interests. As such challenges to the dominant science-policy nexus have resulted in calls for research decision-making and agenda setting to become more transparent and democratically accountable. In terms of practice, this has been embodied in a desire to see increasing public participation in science. However, while there have been calls to widen participation in science, there are a number of different rationales underpinning these call, each with different consequences for science-policy practice.

Chapter 3 Methodology

As discussed in the previous chapter, just as there are many conceptions of discourse, so there are many ways to go about doing discourse analysis. This is true, even within a particular theoretical tradition. For example, while the study by Hajer (1995), comprises a detailed and temporally explicit longitudinal analysis of the rise of the ecological modernisation discourse in relation to acid rain in the UK, other studies (that may be considered as operating in the post-structuralist tradition) have focused on specific events or policies, with an aim of identifying different discourses (e.g. Ockwell and Rydin, 2006). These different approaches also demonstrate the different ways in which discourses are applied to the analysis. Thus, while some authors have identified discourses directly from policy literature and broad reading of the policy area under study (e.g. Hajer, 1995; Richardson, 1997), others have used theoretical frameworks from the academic literature and applied them to a study (e.g. Sharp, 1999; Backstrand and Lovbrand, 2006). Discourses rest on assumptions, judgements and contentions and while there are no set methodological approach to discourse analysis, it is an exploration of these that form the basis of discourse analysis.

This chapter sets out the aims and methodological approach used in this thesis. Discourse analysis is essentially an interpretive work, and logic and credibility of argumentation, backed up by quotes from the texts, are the main 'validity' tests in this kind of analysis. While this thesis utilises a broad environmental discourse typology (see 3.3.3; Dryzek, 1997) to help make sense of the debate over the sustainability of bioenergy, it also draws on a number of other relevant insights. Specifically, from the policy studies literature, the concepts of storylines and discourse coalitions (i.e. Hajer, 1995), and from STS the existence of subtle but different rationales/discourses over the role of participation in science (see chapter 2; Fiorino, 1989; Stirling, 2004). This chapter is split into three sections. The first section describes the selection of the research projects. Section two describes the use of documentary evidence and the interview process, and section three focuses on the analysis and includes a description of the discourse typology this thesis uses to explore the

debate over the sustainability of bioenergy. The chapter begins with a re-cap of the primary aims of this thesis as set out previously in the introductory chapter.

Aims

To explore how research-council funded bioenergy science has engaged with the politics of a sustainable bioenergy.

Specific questions

This thesis approaches the primary aim of this thesis through answering the following questions:

1. How does UK energy policy discursively construct bioenergy, and how are these constructions challenged?

2. How have research-council funded bioenergy projects engaged with the wider discursive struggle over the sustainability of bioenergy, in terms of the constructions that they (re)produce and in the way they practice their research (in terms of content, aims and organisation)?

3. How have the discursive commitments of scientists been reproduced or constrained within the respective project?

3.1 Identification of research projects for study

Given that this thesis is concerned with discourse defined as both text and practice, the focus of the research was conducted around a number of large multidisciplinary projects. The primary reason for looking at individual projects was because this thesis is concerned with research council funded science and these projects are the operational units of that research. As these projects represented the vast majority of research into bioenergy sustainability, taking a project centred approach did not compromise any exploration of the discursive

work research-council funded science does. These project entities, with their specific funding structures (which differ between projects) and disciplinary organisation are the basic practices which structure the way scientists engage with the politics of bioenergy in their research. It was thus viewed as vital to explore this in the context of project organisation. The objective when selecting projects for this thesis was to select those projects that were most engaged in assessing or 'ensuring' the sustainability of bioenergy. While initially it seemed as if this might involve much subjective wrangling, the demarcation between suitable and non-suitable projects was fortunately quite distinct. The particular projects were chosen using a number of criteria, including focus and timing. In terms of focus, it was important that all of the projects were explicitly focused around researching bioenergy in the context of sustainability. It was also important that the projects (or programmes of work in the case of UKERC) were to some degree also explicitly interdisciplinary. This thesis is not concerned with surveying a representative sample of all projects that utilise the language of sustainability in their research proposals. Some form of interdisciplinarity is seen as an essential requisite of sustainability research of this kind (outside of those few perspectives that see no role for science in sustainability, the basic need for an interdisciplinary science to address sustainability concerns appears uncontested), this was to ensure that the projects were most likely to be engaging with sustainability as a concept and potentially integrating its tenets into practice, rather than using it more superficially.

3.1.1 Research-council funded bioenergy research

Energy research within the Research Councils is led by the Engineering and Physical Sciences Research Council (EPSRC) under the Research Council Energy Programme (see appendix 1 for a short review of the structure of bioenergy research in the context of UK science policy). The Energy Programme had a budget of around £70m in 2007/2008, up from about £40m in 2005/2006. The most significant investment in energy research is currently EPSRC's unilateral programme for nuclear fusion. The Energy Programme subsumes two previously existing large multilateral research programmes with

funded bioenergy projects, Towards a Sustainable Energy Economy (TSEC), and Sustainable Power Generation and Supply (SUPERGEN). The Biotechnology and Biological Sciences Research Council (BBSRC) funds a modest amount of unilateral strategic energy crop research, mainly through Rothamsted Research and the Institute for Grassland and Environmental Research (IGER), although it has recently announced a major (£20m) unilateral bioenergy research programme. The Natural Environment Research Council (NERC) also unilaterally funds some research through the Centre for Ecology and Hydrology. Despite this research, the vast majority of bioenergy research however has been conducted through large research programmes funded by multiple Research Councils.

3.1.2 Identification of relevant initiatives

Relevant projects were identified through a comprehensive search of UK funded projects using DEFRA's database of UK public research on non-food uses of crops, UKERC's Research atlas, the BBSRC oasis database, EPSRC project database, and NERC grants on the web. A review of these literatures and funding agency websites only identified a small number of projects that had been or were explicitly involved in research in the context of sustainability. Many of these projects were monodisciplinary (mainly engineering/technology development) and obviously had used conceptions of 'sustainability' or 'sustainable development' fairly narrowly. This left four large studies; TSEC-BIOSYS, SUE-waste, SUPERGEN-Bioenergy consortium and RELU- Biomass (Since this PhD began RELU have also funded another interdisciplinary project focusing on biogas from anaerobic digestion).

Although not solely focused on bioenergy, UKERC was also identified and considered appropriate as it was involved in conducting interdisciplinary research into bioenergy under a number of themes, including its 'environmental sustainability' theme'. All of the projects listed above, apart from SUE-waste were utilised. The primary reason for excluding SUE-Waste was that much of the conflict over bioenergy is related to its land-use function, and it is this that is

central to the controversy over the sustainability of bioenergy. Due to time and resource constraints, it was decided that while inclusion of this project may have been interesting, due to its explicit exclusion of consideration of land-use issues (because of its focus on waste resources only) it was not included. The small number of studies identified, is corroborated by UKERC. In developing its 'research atlas' UKERC has recognize that the carrying out of "applied sustainability research in the bioenergy area has been limited" (UKERC, 2006). The initiatives focused on in this thesis are listed below and their associated funding programmes are described in figure 1. Further information on the projects is also provided in appendix 2

1. SUPERGEN-Bioenergy

The SUPERGEN initiative aims to help "the UK meet its environmental emissions targets through a radical improvement in the sustainability of power generation and supply". The programme is led by EPSRC, but also funded by BBSRC and NERC. SUPERGEN-Bioenergy1 (£2.9m) ran from November 2003 until November 2007, while a second phase of funding (£6.4m) was secured to extend the project until 2011. Phase 1 of the project consisted of 5 work packages and a networking plan. In phase one, theme 1 was concerned with sustainability directly, in terms of considering the wider non-technological aspects and impacts of bioenergy. In phase two, this 'systems analysis' is theme 6. While a large amount of research was undertaken in phase 1, the majority of this focused on combustion modelling, and technology and crop development. Work package 1 was designed to be the theme that drew all of the other themes together and provided a more holistic assessment of bioenergy in terms of its economic, environmental and social dimensions. This theme was thus involved in the carrying out of stakeholder engagement, local and regional scenario construction and analysis, and life cycle analysis (LCA) reviews.

2. TSEC-BIOSYS

The £2.5m TSEC-BIOSYS ‘a whole system approach to analyzing bioenergy demand and supply: mobilising the long-term potential of bioenergy’’, was commissioned in Nov 2005 and ran for 42 months, until May 2009. The project is funded through the TSEC programme, that aims to “take a whole system approach to renewable energy research”. The programme is funded by the Economic and Social Research Council (ESRC), EPSRC, NERC, BBSRC and CCLRC. Conducting “innovative multi and inter-disciplinary research from a whole systems perspective”, TSEC-BIOSYS aimed to develop a framework for whole systems analysis and research on bioenergy that will lead to credible scenarios and a roadmap for the development of the UK’s bioenergy sector. One of its primary objectives was to “assess the implications and sustainability of large-scale bioenergy use and its potential contribution to UK energy and environmental objectives”.

Compared to the SUPERGEN initiative which is predominantly engineering based, TSEC-BIOSYS was much more concerned as a project with the assessment of bioenergy rather than its development. While the entire project is set in the context of sustainability, theme 3 of the project was, unlike any of the other themes, explicitly engaged in sustainability assessment. A large part of theme 1 involved the development and analysis of bioenergy scenarios using (and in the process updating) the MARKAL model. Theme 2 involved the ecological, hydrological and GHG assessments of energy crops as well as productivity modelling and crop technology work. Theme 3 primarily involved the development of a sustainability framework using both qualitative and quantitative techniques. This theme also involved stakeholder engagement workshops, centred around particular case projects.

3. UKERC

UKERC is a multi-institution centre that aims to coordinate and lead UK energy research and feed into the Bioenergy funders forum. Phase 1 ran from April

2004 until April 2009 and had a budget of £14m. Funding has now been renewed (£18.5m) for another 5 years, running until 2014. UKERC differs from the other projects in that rather than representing a bounded research exercise, its remit is much broader in both function and scope, and as such research into bioenergy only represents a small part of UKERC's remit. UKERC 1 was organised around six themes that address clearly defined problems and areas within the energy sector as a whole. Three themes reflect the structure of energy markets: demand reduction, future sources of energy, and energy infrastructure and supply. The three remaining themes are cross-cutting: energy systems and modelling, environmental sustainability, and materials for advanced energy systems. Other activities include a technology and policy assessment function, research road-mapping activity to inform funding decisions, a research portal which maps out the UK energy research landscape, an interdisciplinary PhD training programme, and a networking function known as the meeting place.

Bioenergy research within UKERC falls indirectly under several different themes and is carried out accordingly. However, bioenergy is also one of the technologies explicitly considered under its 'environmental sustainability theme'. UKERC undertook a road mapping exercise for bioenergy research, and the technology and policy analysis function has completed a review of the role of policy in cutting carbon emissions in the transport sector. Bioenergy is also included in the UKERC 2050 project co-ordinated by the 'energy systems and modelling' theme. This project involved scenario based modelling up to 2050 and drew on all of the UKERC themes. The modelling was conducted using the least-cost optimisation model MARKAL and model variants to construct a number of low carbon and energy secure futures. While bioenergy only represents a component of UKERC's research effort, one way that UKERC differs from the other three case projects is the way bioenergy research is framed in the context of the energy system as a whole.

4. RELU- Biomass

The Rural Economy and Land-Use programme does not fall under EPSRC's energy programme. The programme was initiated in order to inform policy and practice with choices on how to manage the countryside and rural economies. RELU is led by ESRC, but also funded by BBSRC, NERC, DEFRA and SEERAD. RELU enables researchers to work together to investigate the social, economic, environmental and technological challenges faced by rural areas, and promote "sustainable rural development". The programme is unique in that it has involved an extended suite of stakeholders, including at certain stages the general public in every stage of the programme; from agenda and priority setting through to the appraisal and commissioning of proposals (for a review of the RELU programme see Lowe and Phillipson, 2006)

'The RELU-Biomass: social, economic and environmental implications of increasing rural land use under energy-crops' project was funded in 2006. Unlike the other projects, while smaller (financially and members wise), it is also more bounded in focus. This four year £859K project integrates social, economic, hydrological and biodiversity studies in an interdisciplinary approach to develop a scientific framework for Sustainability Appraisal (SA) of the medium and long term conversion of land to energy crops. In this way, RELU-Biomass intends to "provide a comprehensive platform upon which to assess the implications of increasing land use under energy crops". RELU-Biomass is examining the "sustainability of SRC willow and miscanthus" through comparison with arable crops and grassland and by comparing rural economics, social acceptability, landscape character, water use and biodiversity. The whole project is built around the construction of an interdisciplinary Sustainability Appraisal (SA), into which all of the other aspects feed. There is a strong stakeholder engagement aspect to the project and representatives from South West of England Regional Development Agency (SWRDA), East Midlands Development Agency (EDMA), DEFRA (Sustainable Farming Food and Fisheries) and the energy crop industry (Bical and Coppice Resources Ltd) have had input and consultation during the development of the proposal. The

building of the SA has also depended on input from two large stakeholder meetings.

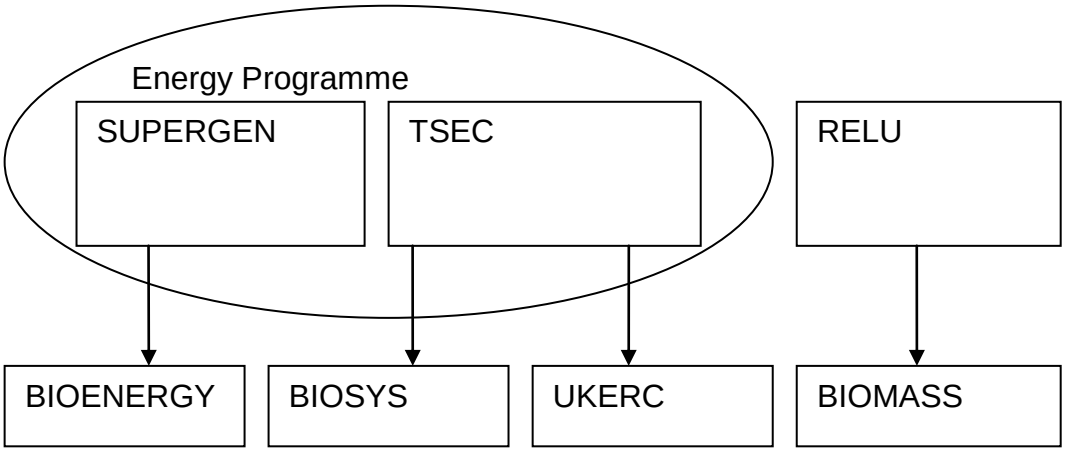

Figure 1. Structure of research-council funded bioenergy research in the UK

While UKERC can not be considered as a bounded project as such, when discussed as a collective for ease the term 'research project' or 'project' will often be used to describe all four initiatives. It is suggested that at the time of survey (2007), these projects (excluding SUE-Waste, which is discussed above) represented the only projects to meet the following criteria:

1. The projects are explicitly involved in carrying out research into bioenergy in the context of sustainable development
2. The projects are at face value interdisciplinary, involving both ecological and social sciences
3. The issue of land-use is addressed in the project remit

The four research projects used in this thesis, were all funded at different times, and therefore also at different 'stages' in the debate over the sustainability of bioenergy. Thus while there are apparent similarities and generalisations that can be made about 'science and sustainability' in general, it is deemed

important to relate this to the temporal development of the debate over the sustainability of bioenergy. SUPERGEN-Bioenergy was commissioned in 2003 (SUPERGEN-Bioenergy 2 in 2007), UKERC at the end of 2004, TSEC-BIOSYS at the end of 2005 and RELU-Biomass at the beginning of 2006. The programmes can thus also be viewed as a timeline of research into bioenergy. However, while SUPERGEN-Bioenergy was funded prior to much of the controversy over the sustainability of bioenergy, the funding of the other three initiatives coincides with the first publication of a number of reports highlighting the potential environmental and social impacts of an expanding biofuel sector (i.e. Monbiot, 2004; RTFO consultation, 2004; FOE, 2005; E4 tech, 2005). While it is possible to draw conclusions as to the way individual projects have approached the subject of bioenergy and sustainability, given that the projects represent the majority of research into the sustainability of bioenergy during the time period 2003-2008, it is also possible to use these initiatives to say something about bioenergy research as a whole.

3.2 Data sources

The three questions this thesis poses are approached primarily through the use of interviewing and document analysis. While the first question relating to the wider discourses operating around bioenergy makes use primarily of documentary analysis, the other two questions draw primarily on interview data. This section will now describe the collection of the document and interview material.

3.2.1 Documentary evidence

Analysis, particularly of the wider debate over the sustainability of bioenergy, is drawn from many sources. However, while much of the context for the analysis came from the authors wide reading of the primary policy literature, to address the first question documentary evidence from the following sources was also thoroughly analysed:

The 2003 Energy White paper (DTI, 2003)
The 2007 Energy White paper (DTI, 2007)
The 2007 Biomass strategy (DEFRA, 2007)
Transcripts from a Westminster Energy and Transport Forum seminar: The future of biofuels (held in May 2008)

In addressing the first question a wide range of 'core' literature could have been drawn upon. However, the sources above were all selected for a number of reasons. The 2003 Energy White Paper represents the first time the government set out it new 'sustainable energy policy'. It also sets the agenda for strategic energy research during the commissioning of all of the research initiatives analysed in this thesis. While the 2007 White Paper reiterates much of the same message as the 2003 paper, it is included as it was also published during the operation of all of the case-study projects. The 2007 Biomass strategy represents the first detailed account of bioenergy in the context of energy policy. Although more recent publications, such as the 2009 Renewable Energy Strategy (HM Government, 2009b) discuss bioenergy, this document represents the richest discussions of bioenergy. The Government's position (e.g. as set out in the 2009 RE Strategy) also does not differ markedly. While many sources could have been used to explore the wider debate over bioenergy, the Westminster Energy and Transport Forum seminar provided an excellent resource for a number of reasons. Having attended the seminar, the author of this thesis had a good contextualised knowledge of the seminar, as well as full access to the transcripts from the event. It was a high level event, attended by government ministers, NGOs, scientists and businesses, and so represented a good cross section of the debate. Also it provided a good opportunity to analyse 'language in practice', including argumentation.

The research projects of interest all maintain project websites, which function as their primary medium for communication with the general public (pers. com. with various project members). While the websites provide varying levels of information regarding the projects, they are similar in providing one or two

pages devoted to introducing bioenergy, setting the socio-political context for their research and providing a brief summary of their aims and objectives. TSEC-BIOSYS, UKERC and SUPERGEN-Bioenergy are all funded through the energy programme, and as such an EPSRC Energy Programme web-page introducing bioenergy will also be considered in this analysis. While not affiliated to any one project, this page provides a useful, replication of the themes presented in the individual project communications. In contextualising aspects of their communication some consideration will also be given to the websites of their funding bodies. All of the web-pages were downloaded on the same date (10/10/2007). While the amount of documentary evidence that could have been drawn upon to answer the first question was vast, the documentary evidence relevant to the second question was more bounded and included:

1. Research programme web sites
2. Research project web sites
3. Publicly available project and programme documents and outputs

3.2.2 The interviews

The interview strategy had two primary functions. The first of these was to help answer question 2 with regard to providing insight into the projects in terms of the research being carried out within them and their general functioning. The second aim was to address question 3 with regard to exploring individual narratives on bioenergy, sustainability and the projects (The full interview schedule can be found in appendix 3). In order to answer question 2 of this thesis, the interviews needed to provide information on: What research the projects were carrying out; what the projects primary aims were; how the projects interacted with non-academics; what the function of the interaction was; how the projects were organised in terms of interdisciplinarity and interactivity; and the experiences of the project members with regard to interdisciplinarity and interactivity.

Answering question 3 was less straight forward than the more structured information needed for question 2, and required in many respects a much less structured approach. In exploring individual perceptions of bioenergy, sustainability and the projects it was necessary to draw on the literature on these topics to structure the questions. Thus in talking about sustainable development and science, interdisciplinarity and interactivity in the context of increasing the relevance and legitimacy of science in research for sustainable development was included as an issue for exploration. In order to address question 3 of this thesis, the interviews thus needed to explore the interviewees' perspectives on: bioenergy, including current policy and desirable futures; sustainable development; science and sustainable development; the role of the projects in sustainable development; interdisciplinarity and relevance in research; and interactivity and legitimacy in research.

The two aims of the interviews were not completely separable and much of the discussion over interdisciplinarity and interactivity in research and on the project informed both question 1 and 2 of this thesis. Given the complexity of the topics under discussion and the underlying 'constructionist' approach assumed in this thesis, the interviews were semi-structured in nature (Kvale 1996). Thus while a prepared interview schedule was used, the interviews were executed in a flexible manner, allowing respondents to as far as possible discuss concepts on their own terms. It also allowed the interviews to adapt to the train of conversation between the interviewer and interviewee, and for deeper dialogue over some of the more difficult concepts, such as sustainable development. While the majority of the interviews were conducted using the same schedule, this approach to interviewing allowed for the schedule to be modified somewhat for a small number of the interviews in which more specific information about a particular aspect of the research or the project as a whole was of interest.

3.2.3 Choice of interviewees

A total of 31 semi-structured interviews were carried out with project members. In order to select participants, a list of project members was drawn up using

staff lists published on the project websites. While this was not straightforward, a reasonably accurate picture was attained. While some published lists of project membership were incomplete, it appeared that most people involved in the projects were identifiable from documentary sources. The more difficult aspect involved judging the degree to which individuals nominally associated with the projects were actually involved in projects. Individuals working on the projects often had various levels of involvement (some listed personnel actually had very little or no involvement in the project), and often more people were listed than were actually involved in the projects. Individuals who were deemed not to be involved or only superficially involved are not included in the information below. There were also a couple of individuals who left and joined the projects, and those who left before the end are also not included. The lists include Research Assistants, Research Fellows and other postdoctoral positions dependant on their involvement in the projects. PhD students are not included in the data. However, as explained below, the author did include an interview with 1 PhD student. Working out the disciplinary spread on the projects was also difficult for a number of reasons. Many people interviewed did not consider themselves affiliated, or only affiliated loosely to any particular discipline. Instead of forcing individuals into categories, the categories used are broad and different categories are used for different projects.

Through a review of available project literature and contact with project members a number of ‘key’ project members were identified for interview. These individuals were identified as desirable from the point of view of being likely to hold certain information regarding the organisation and aims of the case projects. For example, the PI of each project bar one was interviewed (in this case a researcher with effective authority over the project was interviewed in their place). While in some projects only a small number of people were explicitly involved in coordinating the broader ‘sustainability’ aspects or themes of the project, it was made sure that these individuals were interviewed.

Apart from these ‘key’ individuals, the interviewees were selected to provide a wide range of demographics, particularly in relation to discipline, seniority within the project, and project being worked on. Using institution staff web pages,

contact with individuals at conferences and meetings, individuals were then also typed by discipline (broadly as engineering, natural science, social science and more specifically where possible), institution and position within project (where appropriate, e.g. PI's, group leaders, senior researchers, post-doctoral researchers, research assistants and postgraduate researchers). Individuals interviewed thus did not necessarily reflect the disciplinary make up of the project, but instead tended to represent their diversity. Candidates were also selected according to their level of involvement in the projects, and a certain amount of research had to go into making sure that potential interviewees were fully engaged in the project of interest.

While one PhD student was interviewed because of their direct involvement in a particular aspect of one of the projects, all other interviewees were senior academics. The total number of interviewees from each project are listed in table 1 below. The total is higher than the total number of interviews as some individuals were involved in multiple projects. The low number of interviews with UKERC members was due to the limited number of people directly involved in bioenergy research within this programme.

Table 1. Showing the spread of interviews conducted on the case-study projects

Project	Interviewees	Project membership
SUPERGEN-Bioenergy	8	26
UKERC	4	N/A
TSEC-BIOSYS	13	34
RELU-Biomass	9	14

It was hoped that this indicative approach would provide a greater insight into project dynamics than a purely random sampling technique[2]. Thus, the selection of participants can be considered indicative rather than representational. However, choice of interviewees was also to some extent dictated by resource availability. Thus, while a broad a range of institutions as possible were surveyed, the opportunity to interview multiple candidates at the same institution was readily taken. The main constraint on the selection of interviewees was cost of travel and accommodation, and interviewing individuals at the same institution led to the carrying out of a larger number of interviews than would otherwise have been possible.

3.2.4 Interview preparation

After potential interviewees had been selected, all were contacted by e-mail. This first e-mail contained a description of the research and a formal request for an interview. The e-mail also indicated the predicted length of the interview (about 1 hour), conveyed that the interview would be conducted under conditions of confidentiality and anonymity, and contained an outline of the main points that would be discussed in the interview. While the inclusion of an outline of the interview schedule was deemed useful to help explain the project, this was limited to the broad areas to be covered as a certain degree of spontaneity and unstructured discussion was a desired part of the interview. After approximately two weeks, those individuals that did not reply to the e-mail were contacted again by telephone.

Of a total of 50 individuals contacted for interview, 31 were actually interviewed. Of the 19 others, 3 declined due to their lack of involvement in the project of interest, 3 were unable to due to time constraints, and 12 were not contactable by phone or e-mail. One other individual declined on epistemological grounds,

[2] As well as factors, such as a heavy engineering bias and small sociological component to one of the projects, which could have resulted in a random sample only generating engineers to interview, the qualitative approach of this study's methodology did not require this type of representational approach.

questioning the legitimacy of qualitative research. Fortunately all of the identified 'key' individuals responded and were subsequently interviewed, and the non-responses did not affect the desired disciplinary spread to be interviewed. The interview strategy was thus deemed successful in its goals to get an indicative spread of individuals and key actors within the projects.

It was decided that the interviews should be conducted under conditions of confidentiality and anonymity for a number of reasons. While the prospect of being able to link quotes with individuals in the analysis of the interviews was undeniably tempting and potentially analytically powerful, it was decided that this was less important than the increased freedom anonymity conferred on participants wishing to discuss potentially sensitive issues. While much of the interview was unlikely to prove contentious, some, particularly that concerning the relationship between disciplines (manifest as interaction with colleagues) and relationships with non-academics was potentially sensitive. In retrospect this decision was fruitful and on numerous occasions interviewees asked for reassurances about the anonymity of the interview before commenting on particular issues. While some of the interviews felt restrained, the interviewer developed a good rapport with many of the interviewees, and a lot of them felt very open and honest.

3.2.5 Carrying out the interviews

All of the interviews were carried out between the 21st May and 25th July 2008. Of the 31 interviews, 30 were carried out face to face, with one being conducted over the telephone. All of the face to face interviews were conducted at the participant's place of work. The author contacted interviewees two or three days before the interview to remind them of the event. At the beginning of each interview the interviewer reminded the interviewee of the aims of the research, the probable length of the interview, and the confidential and anonymous character of the interview. Permission to record the interview was also sought before recording commenced. All interviews were recorded using a digital voice recorder. In order to get dialogue going, the interviews began with a general

question regarding the research the interviewee was engaged with as part of the project of interest. While the interviewer had a schedule to guide the interview, in many cases the interview didn't follow the ordering of the schedule. The interviewee was allowed to follow trains of thought as much as possible. In these instances the conversation was allowed to flow and the interviewer made notes during the interview to come back and cover points that had been skipped.

Given the conversational nature of the interview style, the interviews sometimes wandered off subject. This was allowed to happen up to a point, as an aim of this sort of interviewing is to allow respondents to answer questions in their own way. It is also important as it allows respondents to raise issues that may have been overlooked or deemed as unimportant by the interviewer. The interviewer occasionally provided feedback to the interviewees in terms of short summaries of the previous discussion, in order to either stimulate expansion of a topic or elicit conformation about certain views the participant had expressed. After conducting the interviews a number of less formal follow up interviews were carried out in order to clarify certain issues regarding the nature of the research on these projects. As, all of the projects were still running during the interviewing period, some of these follow up interactions were also designed to get a clearer understanding of ongoing work.

3.2.6 Reflexivity

One important consideration in the conduct of interviews such as these, is the assumed power relations between participants (Kvale, 1996), and the impacts these might have on the outcome of the interview. However, given the context of the interviews (a PhD candidate interviewing senior academics about their own research and subject areas), it was assumed that these concerns over power were not as applicable. As such the interviewer felt comfortable engaging in lively conversation with the interviewees. While the interviewer never directly disagreed with the interviewees, the interaction was questioning and the interview felt free to engage in discussion with the interviewee without risking

intimidation. One concern was that the interviewer's status as a UKERC funded PhD student may have led to suspicion on the part of some interviewees over the purpose of the interviews. While the effects of this are difficult to judge, considerable effort was made in advance of the interviews to transparently set out the aims and purpose of the interviews. Given the positive responses of most of the interviewees and the ease of conversation generated, it is assumed that this was not an important factor in shaping the interviews. However it is likely that being an UKERC student may have actually been a benefit in gaining access to interviewees. Thus all of the interviewees knew of and had some form of contact with UKERC, acting as it does as a networking organisation.

While this thesis is a sociological work, the interviewer's training (BSC. and MSc.) is in the biological sciences. While this presented many challenges in terms of moving between epistemological frameworks (see chapter 2) and associated disciplinary approaches to data collection, it also provided many advantages. Many of the interviewees were natural scientists and engineers, and it became obvious that being trained in the natural sciences made discussing, what in many instances was highly technical subject matter, easier and more productive. Having been a 'natural scientist', also seemed helpful in building rapport with some interviewees. It is possible that it made some interviewees feel more comfortable talking about their research and also provided a certain amount of topic to help start off discussions.

3.3 Analysis

This section will focus on the process of analysis. Many of the broad concepts used for analysis were introduced in the previous chapter, and where necessary cross references will be made. While similar approaches to the analysis of the documents analysis and the interview data where made, there are differences between the two. The most obvious of these being the much closer textual analysis applied to some of the documentary evidence.

Discourse analysis, as approached in this thesis, has a number of aims. In trying to make sense of political struggle, this thesis attempts to both reveal the role of language in politics and to reveal the embeddedness of language in practice (Hajer and Versteeg, 2005). A basic assumption of discourse analysis is that, rather than neutrally reflecting reality, language profoundly shapes one's view of the world. In tracing particular linguistic regularities found in discussions or debates, discourse analysis may illuminate particular discursive structures that might not be immediately obvious to the people that contribute to the debate. Because a particular discourse has its own argumentative rationality, tracing discourses might also shed light on the democratic quality of discussions (Hajer and Versteeg, 2005). Viewing discourse as the engine of social change, this thesis is based on the assumption that not only does it matter how bioenergy science contextualises its work and potentially reproduces particular understandings of sustainability, but it also matters how this manifests in practice.

3.3.1 Pre-analysis and basic coding and analysis in NVIVO 8

All of the interviews were fully transcribed by the author. This also allowed the author to re-engage with the interviews prior to the main task of analysis. Transcribed interviews as well as the three strategy documents and the transcripts from the Westminster Energy and Transport Forum were then imported into the qualitative software package, NVIVO 8. NVIVO 8 is a piece of software that is designed to help organise, code, and analyse large bodies of qualitative data. While it is a useful tool for the qualitative researcher, it is only a tool and the ideas must come from the researcher. However, it does provide an invaluable service in terms of allowing large amounts of data to be organised and re-organised quickly. It also provides various ways of looking at, linking and categorising data.

In NVIVO 8 it is possible to easily code and recode data from different sources. While retaining the original data files (e.g. transcripts), after coding different sections of the transcripts under different themes, it is possible to quickly view

all material assigned to one theme. Themes can be created as part of a hierarchically ordered coding tree, which allows the development of a number of different ‘themes’ and ‘sub-themes’. Much of the data from the interviews regarding specific aspects of the projects and specific research activities was dealt with in a straightforward manner and coded accordingly. While the original interview schedule was built around a number of themes drawn from the literature (see below) as well as prior knowledge of the research projects in question, the specific coding also partly emerged out of the interviews themselves. Thus while the first level themes concerning the broad categories of ‘bioenergy’, ‘interdisciplinarity’, ‘interactivity’, ‘sustainable development’, ‘science in sustainable development’ remained from the interview schedule, many of the second level themes emerged out of the interview process and subsequent analysis phase. Coding the transcripts was thus in some respects an iterative process.

All of the data (including the other documentary and transcript data) was also coded using Dryzek’s (1997) typology (see sections 3.3.3), and iteratively using the emergence of identifiable storylines. By the time the transcripts had been coded the author had an intimate knowledge of the material and it was possible to work with the individual themes with a broad knowledge of the data as a whole. While many of the ideas were developed during the coding process, it was also necessary to try to triangulate certain issues through corroboration with other transcripts. Thus while analysis involved looking for where opinions and perspectives diverged or converged, It also involved a degree of testing of certain claims and opinions (Miles and Huberman 1994). While this ‘pre-analysis’ phase is listed here before a consideration of the use of the more theoretic tools and ordering devices, the analysis was not a strictly linear process.

3.3.2 Doing discourse analysis

While there is no set methodological approach for doing discourse analysis, this thesis draws heavily on John Dryzek’s (1997) approach. In this simple

approach, Dryzek asks us to do three things. The first is to question the assumptions, justifications and claims that underpin a discourse, the second is to search for the metaphors and rhetorical devises that are used to reinforce the discourse, and the third is to explore what impacts this discourse has on aspects of practice. This approach reflects approaches put forward by others working in critical discourse analysis (CDA). Although born of different traditions (critical theory and linguistics respectively), both Dryzek (1997) and Fairclough (1992) provide similar frameworks for going about discourse analysis. As such before going into more detail as to how the data collected in this thesis was interrogated, Figure 2 provides a useful way to conceptualise the different 'levels' of analysis undertaken in this thesis.

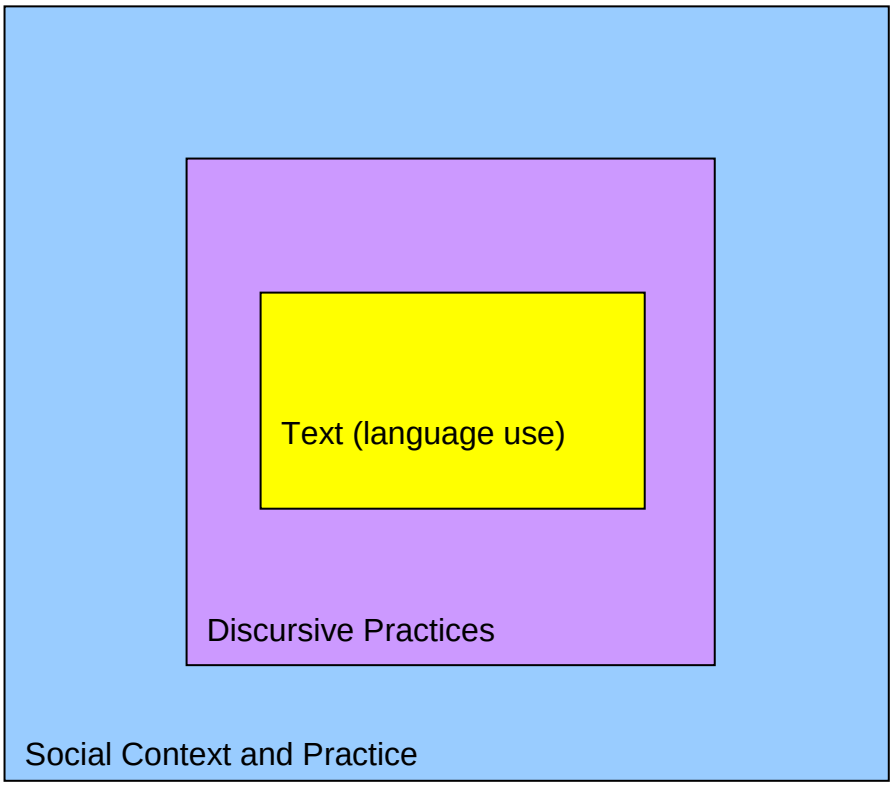

Figure 2. Showing a three-level conception of discourse for use in CDA (Taken from Fairclough, 1992, 1995)

Discourse analysis in this way is conceived of as an interdisciplinary endeavor, involving aspects of linguistics, psychology, sociology and political science. While CDA is not a strict method for discourse analysis, it provides a useful way of thinking about the link between the use of language and aspects of social practice. While focusing on Textual analysis, in providing a framework for analysing social change CDA attempts to bring together three analytical traditions, each of which is considered indispensable for discourse analysis (Fairclough, 1992). These are the tradition of close textual and linguistic analysis within linguistics, the micro-sociological tradition of seeing social practice as something that people actively produce and make sense of on the basis of shared common sense procedures, and the macro-sociological tradition of analyzing social practice in relation to social structures.

As well as using a number of analytic tools (detailed below), this thesis follows Dryzek's (1997) approach to discourse analysis. These 'questions' are repeated and expanded on in Faircloughs (e.g. 1992) rationale for critical discourse analysis (CDA). Central to the analysis of discourse from the perspective taken is recognition of the way actors construct their arguments. Dryzek recognises four aspects of language. Thus the primary questions that were asked of the documentary and interview evidence were:

1. **What is the ontology underlying the particular narratives?**
   Thus what assumptions are made or underpin certain claims? What is presented as fact? e.g. if an economist speaks of interventions in a free market, they are implicitly reinforcing the assumption that the market in question is in fact free. Or fuel poverty may be constructed as a real phenomenon rather than just an aspect of poverty.

2. **What kind of relationships that are presented as natural?** For example, are people perceived to be locked into a Darwinian struggle or are people assumed to be naturally cooperative?

3. **Who are the primary actors represented and what are their motivations?** It is necessary to question assumptions about agency and motivation of actors, e.g. are the public conceptualised as ‘citizens’ or ‘consumers’.

4. **What rhetorical practices are used to reinforce these claims?** Rhetoric may be used in discrete messages or to frame wider policy debate. In addition to the use of ambiguity, rhetorical strategies may include identification or differentiation (linking one issue with another, or separating issues), the use of juxtaposition (aligning one thing with another regardless of connection) or substitution (attempting to change the focus of an issue), and dismissal or propaganda (the denial of opposing viewpoints or the assertion that one position is the only position (Cheney et al., 2005).

Reflecting the first three questions in Dryzek’s approach, Fairlcough (1982) identifies three aspects relating to the constructive affects of discourse: the construction of social identities and subject positions; the construction of social relationships between people; and the construction of systems of knowledge and belief. These effects correspond respectively to three functions of language and dimensions of meaning which coexist and interact in all discourses; ‘identity, ‘relational’ and ‘ideational’ functions of language. In analysing the documentary evidence, the analysis also focused on the structural organization of texts (what is chosen for the headline and the first few paragraphs, what is left for the end of the text), and any morphological characteristics (i.e., use of pictures or figures and their positioning). Discursive strategies and ideological standpoints were then inferred from the analysis of these elements in the context of the wider political discourses surrounding bioenergy and sustainability.

Having analysed what might be considered aspects of text, it was also important to explore and understand how particular discourses reflect and help structure particular social and cultural practices. Thus it is important to

interrogate the significance of particular policies and institutions, as well as less obvious practices that might be considered established norms. It is also important to understand the way that more hegemonic discourses structure the possibility of dissent, in terms of accepted forms of knowledge. While much has already been written about energy policy practice (e.g. Helm, 2007; Mitchell, 2008; Slade *et al.*, 2009), of specific concern was the more detailed rationale behind bioenergy policy. As discussed in the previous chapter, potential scientific practices might include the functioning of research around concepts such interdisciplinarity or interactivity with different publics, or particular communication strategies.

3.3.3 A high level typology

A number of frameworks have been developed to classify environmental discourses, and the territory of environmental politics has been divided up by a number of different authors in different ways. Andrew Dobson (1990) for example distinguishes between conservatism, reform environmentalism and radical ecologism, while Robyn Ecckersley (1992) think the major discursive divide lies between 'anthropocentric' and ecocentric' perspectives. Many authors have likewise attempted to classify the complexity of sustainable development discourses into a number of more distinct positions (e.g. Myerson and Rydin; 1996; Dobson 1996; Jacobs, 1999). These are most often organised along a weak-strong, radical-conservative type spectrum, contrasting optimistic positions emphasising the priority of economic growth for both development and environmental protection (such as might characterise the UN and UK government approach to sustainable development) with those more radical positions that question the compatibility of the neoliberal capitalist agenda with environmental protection (e.g. Daly, 1996) and real social justice (e.g. Redclift, 1987; Castro, 2004). However, while these typologies may provide useful heuristic devices, it is clear that they also act to obscure the multidimensional nature of the various perspectives on sustainable development. For example, while the 'strong' conceptualisations are often associated with narratives of environmental protection and social justice (and thus opposed to the 'weak'

focus on economic and industrial development), it is clear that discourses of environmental protection and social justice are often articulated as mutually exclusive to one another (Connelly, 2007). Likewise conceptions of 'strong' sustainability can also differ markedly on their commitment to the role of public participation and democratic reform.

A particularly detailed and influential typology, and the one utilised as a high level heuristic in this study, is Dryzek (1997). Dryzek's typology was deemed most suitable for a number of reasons. The first of these being that it is a rich and well used typology. The second being, that it has been applied (at least in an *ad* hoc way) to energy policy research previously (e.g. Scrace and Ockwell, 2009). Third, while this thesis is explicitly interested in sustainable development, as was already discussed sustainable development is often used to cover a number of different environmental perspectives. As such a broad ranging typology that covered perspectives that may not appear as even satisfying the basic tenets of sustainable development was deemed appropriate.

Dryzek recognises a number of environmental discourses that can be variously distinguished by their degrees of radicalism and their imaginativeness. His resulting four discourse types contain a total of nine different discourse types (summarised in table 2) and show some resemblance to the ideal types of Cultural Theory as set out by the anthropologist Mary Douglas (Douglas, 1982). However, while these discourses are distinct, they are not hard and fast categorisations, but rather idealistic types. This 'greyness' in typology is also reflected in the non-exclusive way that people use different discourses. This context dependant use of conflicting discourses by individuals has led to a long debate in anthropology and social psychology (see, Thompson 1982). Discourses also operate on multiple levels and can be divided up in multiple ways.

Table 2. Showing environmental Discourses, after Drysek (1997)

<table>
<tr><th></th><th>Reformist</th><th>Radical</th></tr>
<tr><td rowspan="4">Prosaic</td><td>Problem solving</td><td>Survivalism</td></tr>
<tr><td>Administrative rationalism:

Basic entities:- liberal capitalism, the state, experts, managers
Assumptions about natural relationships:- nature subordinate to human problem solving, people subordinate to state, experts and managers control state
Agents and their motives:- experts and managers, motivated by public interest, defined in unitary terms
Key Metaphor and other rhetorical devices:- mixture of concern and reassurance, the administrative mind</td><td>Survivalism:

Basic entities:- finite stocks of resources, carry capacity of ecosystems, population, elites
Assumptions about natural relationships:- conflict, hierarchy and control
Agents and their motives:- elites, motivation is up for grabs
Key Metaphor and other rhetorical devices:- overshoot and collapse, commons, spaceship earth, Lilly pond, cancer, virus, computers, images of doom and redemption</td></tr>
<tr><td>Democratic pragmatism:

Basic entities:- liberal capitalism, citizens
Assumptions about natural relationships:- equally among citizens, interactive political relationships, mixing competition and cooperation
Agents and their motives:- many agents, motivation a mix of material self interest and multiple conceptions of public interest
Key Metaphor and other rhetorical devices:- public policy as a resultant of forces</td><td rowspan="2">Promethean response:

Basic entities:- nature as brute matter, markets, prices, energy, technology, people
Assumptions about natural relationships:- hierarchy of humans over everything else, competition
Agents and their motives:- everyone; motivated by material self interest
Key Metaphor and other rhetorical devices:- mechanistic, tends</td></tr>
<tr><td>Economic rationalist:

Basic entities:- Homo economics, markets, prices, property, governments (not citizens)
Assumptions about natural relationships:- competition, hierarchy based on expertise, subordination of nature
Agents and their motives:- homo economics, self interest, some government officials must be motivated by public interest
Key Metaphor and other rhetorical devices:- mechanistic, stigmatizing regulation as ‘command and control’, connection with freedom, horror stories</td></tr>
</table>

	Sustainability	Green radicalism
Imaginative	**Sustainable development:** Basic entities:- nested and networked social ecological systems, capitalist economy, ambiguity concerning existence of limits Assumptions about natural relationships:- cooperation, nature subordinate, economic growth, environmental protection, distributive justice and long term sustainability go together Agents and their motives:- many agents at different levels, transnational and local as well as the state; motivated by public good Key Metaphor and other rhetorical devices:- organic growth, nature as natural capital, connection to progress, reassurance	**Green consciousness:** Basic entities:- global limits, nature, unnatural practice, ideas Assumptions about natural relationships:- natural relationship between humans and nature that have been violated, equality across people and nature Agents and their motives:- human subjects. Some more ecologically aware than others; agency can exist in nature too Key Metaphor and other rhetorical devices:- wide range of biological and organic metaphors, passion, appeal to emotions and intuitions
	Ecological modernisation: Basic entities:- complex systems, nature as waste treatment plant, capitalist economy, the state Assumptions about natural relationships:- partnership encompassing government, business, environmentalists, scientists; subordination of nature; environmental protection and economic prosperity go together Agents and their motives:- partners; motivated by public good Key Metaphor and other rhetorical devices:- tidy household, connection to progress, reassurance	**Green politics:** Basic entities:- global limits, nature as complex ecosystems, humans with broad capabilities, social, economic and political structures Assumptions about natural relationships:- equality among people, complex inter connections between humans and nature Agents and their motives:- many individual and collection actors, multi dimensional motivation; agency in nature down played though not necessarily denied Key Metaphor and other rhetorical devices:- organic metaphors, appealing to social learning, link to progress

It is clear that sustainable development in this typology is a very broad categorisation. Also in this typology it is also only a label, and it is obvious that in everyday usage of the term it may be used to cover a wide range of perspectives. In discussing the role of discourse in policy change, Dryzek

(2003) recognises a number of rigid constraints, which can be identified as a set of core imperatives that governments must abide by. The first three are, maintaining domestic order, surviving internationally and raising revenue. The other two, sustaining economic growth and maintaining civil legitimacy have emerged with capitalist democracies. It is always in the interests of Governments to ensure that initiatives deliver against these core imperatives (Dryzek *et al.*, 2003). It is suggested that the ideas that underpin any new policy framing must also be constructed to speak to the core imperatives if they are to be effective within the evolving context of incumbent institutions, and to be able to alter the way that policy discussions frame problems.

3.3.4 Other analytical tools

While the more structured framework of Dryzek was applied to code the data imported into NVIVO, the author also went into the interviews and document analysis with knowledge of a number of other less structured accounts of potentially useful discursive perspectives and analytical tools; the most obvious of these being the different narratives on participation in science and its relationship with interactivity and interdisciplinarity (as discussed in chapter 2). While these are not necessarily incompatible with Dryzek's (1997) framework, how they fit with this typology is unclear.

While this thesis uses these discursive frameworks to help organise the data collected and help explain the points of conflict or reinforcement, the thesis also draws on the concepts of storylines and discourse coalitions (see chapter 2). Thus, the thesis is also concerned with identifying certain concepts and rhetorical devises that unite certain discursive positions on bioenergy and sustainability. These may not necessary be storylines that reproduce one of these already recognised discourses. They may span these discursive positions, or may even be narrower. As already discussed, 'sustainability' is an obvious storyline, that most likely unites all of the discursive positions these thesis will encounter. However, this does not mean that there is no conflict within the discourse that this storyline suggests. The function of these storylines

is their ambiguity, and different storylines are likely used under different contexts. The identification of storylines was an iterative process, emerging out of the analysis. The other concept this thesis will refer to is ‘discourse coalitions’. While this thesis is not concerned with analysing policy formation or a distinct instance of political change, discourse coalitions provide a useful concept to describe a variety of discursive positions that are temporarily united by a set of storylines. However, as has already been discussed, discourse analysis is essentially an interpretive work, and logic and credibility of argumentation, backed up by quotes from the texts, are the main ‘validity’ tests in this kind of analysis (Carvalho and Burgess, 2005).

Conclusion

This chapter has set out the methodological approach used in the collection and analysis of data in this thesis. The thesis takes a detailed exploration of the role of research-council funded bioenergy research in the politics of bioenergy sustainability. In doing so, it takes a look at the discursive practices of four large interdisciplinary bioenergy research initiatives, explicitly engaged in the researching bioenergy in the context of sustainability. During the time span of this thesis, these projects represented the vast majority of the research looking at the sustainability of bioenergy. While a number of insights from STS and other ‘tools’ developed to enhance our conceptualisation of discourse are drawn upon, this thesis also makes use of a published and widely used ‘environmental discourse’ typology.

Chapter 4:Bioenergy for sustainability

This chapter considers the development of bioenergy under the dominant discourse shaping UK energy policy. The chapter begins with a characterisation of the new 'sustainable' energy policy in the UK. Previously described as a discourse of prosaic reform (Scrace and Ockwell, 2009), this chapter concludes that energy policy in the UK should be instead described as an attempt to implement something like a weak version of ecological modernisation (EM). Through an analysis of the development of bioenergy under EM, the chapter attempts to addresses a number of questions, including, why bioenergy has developed as it has (with such a strong emphasis on imported biofuels)? Why the environmental concerns over bioenergy have had so little political traction? And, why the political challenge to biofuels did not manifest earlier? While the chapter provides an introduction to the now very public debate over the sustainability of bioenergy, chapter 5 goes on to explore the politics of sustainability in more detail. The embodiment of the dominant discourse within particular social is also discussed further in the next chapter.

4.1 Energy policy and sustainable development

The direction of bioenergy development in the UK reflects changing priorities in energy policy over the past 12 years. The focus of energy policy during this time has arguably shifted somewhat in emphasis from liberalization, privatisation and competition to security and mitigation of climate change (Helm, 2003; 2007; Mitchell, 2009). While traditional bioenergy practices, such as small scale burning of wood for heat, have had a long history in the UK, it has been these concerns (security and primarily climate change) that have, at least rhetorically, driven forward the development of a modern bioenergy sector in the UK.

4.1.1 Energy security

While there may be many reasons for an increased emphasis on energy security in energy policy, two tangible drivers have been the rise in international

oil prices at the beginning of the decade and dwindling national oil and gas reserves. After the oil shocks of the 1970s (caused by many different events and culminating in the Iranian Revolution at the end of that decade), most of the developed world experienced recession. In Britain at least, this led to a major drop in demand for energy and an excess of supply. During the 1980s and 1990s oil prices were correspondingly low and the primary goals of energy policy were market liberalisation and competition. As such, during this time much of the electricity system was privatised (Helm, 2003).

However, in 2000 oil prices rose sharply again, but this time unlike before, have not fallen back. While this has been partly due to international tensions and particularly the war in Iraq (Helm, 2007), it has also resulted from an erosion of excess capacity in countries such as Saudi Arabia (Stevens, 2007), and the lack of exploration and aging downstream infrastructure (Helm, 2007). Low prices and the specific design of markets have also discouraged long term contracts for gas, exacerbating the impacts of these other factors (Helm, 2007). As previously predicted, in 2004, due to the depletion of gas and oil reserves in the North Sea, for the first time ever the UK switched from being a net exporter to becoming a net importer of energy (BERR, 2008).

4.1.2 Climate change

In recognition of the global nature of climate change, in 1992 the United Nations Framework Convention on Climate Change (UNFCCC) was agreed at the Earth Summit in Rio de Janeiro. In 1995, the IPCC Second Assessment Report concluded that there was a "balance of probability of discernable anthropogenic effects on the climate" (IPCC, 1995); this is viewed as key in providing impetus for the formation of greenhouse gas mitigation measures at a political level (IEEP, 2005). In the UK, 1997 saw both New Labour coming to power, under a manifesto to reduce CO2 emissions by 20% by 2010 and the international ratification of the Kyoto protocol, to which Britain is a signatory. While concerns about national energy security have been growing over the past decade, it is climate change mitigation and the decarbonisation of the energy sector that has

been forwarded as the primary rationale for renewable energy in the UK (DTI, 2003; Mitchell and Connor, 2004; DTI, 2007).

4.2 The new sustainable energy paradigm

The new focus of energy policy around the issue of climate change led to what Helm (2007) has called the 'new energy paradigm', which he considered as being initiated in 1997 and culminating in the publication of the 2003 energy white paper, 'Our energy future: creating a low carbon economy' (DTI, 2003). The Energy White paper formalised the Royal Commission on Environmental Pollution's, earlier suggestion for the need to decrease carbon dioxide emissions by 60% by 2050 (RCEP, 2000) and the Cabinet Offices Performance and Innovation Unit suggestion to meet 20% of our electricity demand with renewables by 2020 (DTI, 2003). This 'new energy paradigm' was based squarely in the context of sustainable development.

Sustainable development has occupied a place on the global agenda since at least the early 1980s, with the publication of the International Union for the Conservation of Nature's World Conservation Strategy (IUCN *et al.*, 1980) and the Bruntland Commissions' "Our Common Future" (WCED, 1987). The Bruntland Commission defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, 8 and 43). In 1992, the Rio Earth Summit brought sustainable development on to the global agenda, reaffirming the ideas set out in the Bruntland report in its own action plan, 'Agenda 21' (UN, 1992). Although substantively vague, a broad international agreement has emerged that the goals of sustainable development should be to foster a transition toward development paths that meet human needs while preserving the earth's life support systems and alleviating hunger and poverty. This should be achieved through forms of governing that are empowering and also sensitive to the needs of future generations (UN, 2002).

Sustainable development is now the dominant paradigm of development at both the regional and local level, and while sustainable development reflects a broad political consensus, the more specific interpretations of the concept by national and supranational institutions have been criticised from many perspectives (e.g. Escobar, 1995; Daly, 1996; Foster, 2002; Castro, 2004), highlighting the very contested nature of the concept. However, despite its more radical potential (see chapter 5), sustainable development in operation has become increasingly synonymous with concepts such as 'the triple bottom line' (Gray and Milne, 2002 cited in Springett, 2003), 'sustainable economic growth' and ecological modernisation (Spaargaren and Mol, 1992; Hajer, 1995). While sustainable development and ecological modernisation are often conflated in the literature (there are those that see 'Our Common Future' as explicitly ecologically modernistic; e.g. Hajer, 1995), others see them as overlapping discourses (e.g. Dryzek, 1997). However, other analysts see the conflation of the two as more insidious and counterproductive to the broader sustainable development agenda (e.g. Langhelle, 2000).

4.2.1 A Regulatory State Paradigm?

While energy policy and climate change policy have been framed in the context of sustainable development, there is much academic debate as to the characterisation of this policy, and environmental policy more widely as a legitimate strategy for sustainable development. According to Mitchell (2008), rather than reflecting the goals of sustainable development, energy policy as it stands reflects the underlying political-economic paradigm, which has been labelled the Regulatory State Paradigm (RSP) (Moran, 2003). The primary features of the RSP are: that different technology options should compete on price, that competition in general should be supported, that support mechanisms should be 'technology blind', and that policy cost should be minimised. For example, while the UK has set targets for the supply of electricity from RE, the proportion of this to be met by different technologies is not specified, but rather dictated through least cost optimisation mechanisms such as the Renewable Obligation (see below).

While characterising energy policy in this way, Mitchell suggests that these principles are unlikely to deliver the technical, industrial, institutional and human innovation required to address the threat of climate change. While the concept of the Regulatory State Paradigm (RSP) focuses heavily on institutional factors and issues of practice, little reference is made to the role of language. In characterising the RSP as a barrier to sustainable development, it is argued that there is a need to move government policy away from narrow economic quantitative analyses, to analyses which combine economic with technology and innovation theory, and to move from the current undervaluing of qualitative social science to one which appreciates it and incorporates it in the policy framework. While, the RSP is considered by many to be the dominant political paradigm governing energy policy in the UK (Mitchell, 2008; Slade *et al.*, 2009), this is not the only way energy policy has been characterised.

4.2.2 Economic Rationalism or Ecological modernisation?

Scrace and Ockwell (2009) have suggested that UK energy policy is representative of what Dryzek (1997) would label as an 'economic rationalist' repertoire, that also includes administrative measures and limited pragmatic efforts at democratic decision making (e.g. through consultation and planning procedures). Their argument is that constructing climate change as an issue of economic efficiency, explains the success of climate change as an idea in energy policy, as it speaks directly to the government imperatives of economic growth. While this characterisation appear plausible, the combination of economic frames with weak attempts at democratisation suggests that the new 'sustainable energy paradigm' might be better characterised as an attempt to implement something like a weak version of ecological modernisation (Barry and Patterson, 2004).

Despite the critiques of ecological modernisation (see chapter 5), it is claimed that it has become the major discourse and strategy by which industrial countries in the west, frame and approach their environmental problems

(Bluhdorn, 2000). While the EU and the UK are vocally committed to sustainable development, various analysts have drawn attention to the ecologically modernising nature of their agendas. Thus, although not articulated so clearly, the Labour government's environmental policies have been understood to be an attempt to implement something like an ecological modernisation agenda (Dryzek et al., 2002; Barry and Paterson, 2004). This has also been described at the EU level (i.e. Baker, 2007).

However, while the tenets of ecological modernisation may be more defined than those of sustainable development, there is still debate as to its precise definition. Thus a weak interpretation might include the techno-bureaucratic, state-led 'greening of certain aspects of the economy (e.g. Mol, 1996; Hajer, 1995), while a stronger version might assume the extension of democratic decision making processes, deeper re-structuring of the economy and a broader social change that might be called 'reflexive modernisation' (Beck et al., 1994). However, it is the weak form that has driven shifts in discourse about environmental policy more directly (Barry and Paterson, 2004).

Key to weak notions of ecological modernisation is the separation of energy demand and resource throughput from economic growth. The approach is principally technical, focusing on innovation and efficiency in the use of energy and materials. Ecological modernisation stresses market-based incentives and voluntary agreements that direct businesses toward eco-efficient practices, which do not undermine competitiveness and should ideally create new employment, markets, investment opportunities and technology (Barry, 2007). There are two primary reasons why ecological modernisation (at least in its weak incarnation) might be a more accurate description of the new sustainable energy policy. First, the discourses focus on the economic opportunities presented by climate change, and second, there is a strong focus on science and technological innovation as the primary drivers of sustainability.

4.2.3 Sustainable economic growth

The key characteristic of ecological modernisation is that, contrary to much radical thought on sustainable development, continued industrial development offers the best strategy for escaping from the current ecological crises. Ecological modernisation proposes that the era of late modernity offers the promise that industrial development, economic growth and capitalism are not only compatible with ecological reform, but may also be key drivers of this reform (Spaargaren and Mol, 1992; Mol, 1996). Ecological modernisation thus argues for the potential of attaining sustainability from within, 'greening' business as usual, and thereby avoiding any radical restructuring of the economy or social values (York and Rosa, 2003). While the 2003 White paper stresses an unwillingness to interfere in markets (quote 1), and is therefore suggestive of what Dryzek (1997) would classify as economic rationalism, the rhetoric on innovation, "delivery through partnership" and the presentation of climate change as an opportunity to stimulate economic growth (quote 2) suggests an attempt to implement a programme of weak ecological modernisation. As will be discussed in later sections, the support for biofuels as a specific technology also is more suggestive of an ecological modernisation agenda.

> *1. We will not intervene in the market except in extreme circumstances, such as to avert, as a last resort, a potentially serious risk to safety.(DTI, 2003, 6.7)*

> *2. Moving to a low carbon economy also presents opportunities for businesses to seize competitive advantage (ibid., 7.14)*

4.2.4 A reliance on science and technology

Framing climate change as a supply-side issue rather than a demand-side consumption issue (e.g. Mitchell, 2008) reflects the faith put into the role of science and technology as solutions to climate change. Ecological modernisation in the UK has been described as weak, in that it turns largely on the centrality of eco-efficiency and innovation (Barry, 2007). The 2003 white paper and the discourse in general is technologically optimistic, with great expectation invested into a number of advanced technologies such as carbon dioxide sequestration, hydrogen production and storage, solar PV, and wave and tidal power. In these respects science and technology are seen as central drivers of a low carbon future (quote 3).

3. Science and technology are vital (ibid., Ministerial forward)

The focus on science and technology becomes even more pronounced in later white papers (and is discussed further in later sections dealing more specifically with bioenergy). While science and technology are placed centre stage, the discourse portrays individuals as passive and economically rational consumers rather than citizens or political actors. For example, it is assumed that reduced transport emissions will be met through cleaner technologies rather than any transformational reconsideration of our conception of mobility. The assumption that sustainability will be achieved through technological rather than large scale behavioural changes also underlines the agency the discourse endows on the government; an agency limited to the creational and minimal regulation of environmental markets. While the role of partnership is stressed, it is industry that is granted primary agency in delivering the desired objectives, through the provision of clean technology.

4.2.5 Ecological Modernisation in practice

The commitment to consumer capitalism underlying ecological modernisation is reflected in the policies mechanisms associated with the new energy policy.

These focus primarily around decarbonisation of the supply of electricity, through the promotion of new technologies using market based mechanisms. Where demand reduction is supported, this is promoted through eco-efficiency measures rather than through the lifestyle change. While decarbonisation in the UK is directly supported in a number of ways, the primary mechanisms relevant to bioenergy include the Renewables Obligation (box 4), and the Renewable Transport Fuel Obligation (RTFO) (see section 4.3). Other policies that favour RE more indirectly are the Climate Change Levy (CCL) and the European Emissions Trading Scheme (EU-ETS). CCL is a charge directed at the use of fossil fuels in electricity production and the ETS is a cap-and-trade scheme in which large industry must produce emissions permits for each tonne of CO2 they produce.

The Renewables Obligation (RO)

While the Renewable Energy Strategy (HM Government, 2009) has indicated its plans to introduce a renewable heat incentive and a system of feed-in tariffs, since the expiry of the Non-Fossil Fuel Obligation (NFFO) in 2002, the main policy mechanism through which the UK Government supports the development of new renewables capacity is the Renewables Obligation (RO). This acts on licensed electricity suppliers in England and Wales and its equivalents in Scotland and Northern Ireland. The RO was introduced in April 2002 (the Scottish Renewables Obligation Scotland (ROS) was in place in 2000) and sets out incentivised targets for electricity providers to provide a percentage of their energy from renewable sources, ramping from 3.0% in 2003/04 15% by 2015 (DTI, 2003). The RO is guaranteed to stay in place until at least 2037 (HM Government, 2009). While the RO was designed to be a technology neutral approach, aimed at delivering lowest cost decarbonisation, it has recently been amended in order to provide varying levels of support for RE technologies at different stages of development. Thus since April 2009 different technologies now receive different numbers of ROCs per MWh of electricity generated, to reflect differences in technology costs. Under this 'banding', established bioenergy technologies such as landfill gas will receives less Renewable Obligation Certificates (ROC's), while emerging technologies such as CHP using energy crops will receive more.

Box 4. The renewable energy obligation (RO)

While traditionally used for small scale heating, until recently bioenergy use had, in the UK, been in decline. However, this began to change when in 1997 the Commission of European Communities set an aspirational target for almost 10% of the total energy supply for the European Union to come from biomass by 2010 (CEC, 1997). Although the UK did not set any specific targets for bioenergy, it was highlighted as having a "significant role to play" in meeting its own RE targets (DTI, 2003). As well as contributing to decarbonisation in the electricity and transport sectors, it was also claimed that bioenergy would lead to greater decentralisation of the electricity sector, leading to new opportunities for small scale generation. The distribution of gas and electricity in the UK is highly centralised, with the majority of electricity being produced in Scotland and northern England and transmitted to the South of England where demand is highest. Decentralisation of the energy system and the development of smaller scale energy technologies, while not a primary driver for energy policy, are supported by many as a desirable development (e.g. Greenpeace, 2006).

Support for bioenergy under the new 'sustainable' energy paradigm, took the form of a broad range of policy mechanism that reflect the underlying discourse. Of significant financial value have been the £29m Energy Crops Scheme, introduced in 2000 as part of the England Rural Development Programme and the £66m Bioenergy Capital Grants Scheme (Running from 2002 until 2011, with all funds to be allocated by April 2009), run through the Department of Energy and Climate Change's (DECC) UK Environmental Transformation Fund. Both of these schemes have provided upfront payments the planting of second generation energy crops and deployment of bioenergy plant respectively. Support for biofuel has been delivered through fuel duty incentives (biodiesel and bioethanol are taxed at 27.1p per litre; 20p per litre less than fossil petrol and diesel). This support is guaranteed until 2010 (DEFRA, 2007). The biodiesel and bioethanol incentives have been in place since July 2002 and January 2005 respectively.

The primary support measures for bioenergy however, is the RO (discussed above), and the Renewable Transport Fuel Obligation. While the UK has

binding targets for the supply of biofuels (see below), it has no binding targets for the contribution that bioenergy might provide in a future electricity and heat mix. However, bioenergy has always been expected to play a significant role in meeting the UK's renewable energy and decarbonisation commitments. These commitments currently amount to a 15% renewable energy contribution by 2020 and an 80% reduction in CO2 emissions by 2050 (HM Government, 2009a). Analysis for the Renewable Energy Strategy (RES) indicates that nearly a quarter of the UK renewable energy target could come from bioenergy in the heat and electricity sectors (HM Government, 2009b). This is on top of that supplied as biofuels. However, it is also conceded that to do this the UK would need to import much of this from sources abroad.

4.3 The RTFO and Biofuel debate

In 2001 the EU published a proposal for the promotion and use of biofuels for transport, which was enacted in 2003 in the form of the EU Biofuels directive. As this directive required that member countries set targets for the supply of biofuels, after setting targets for biofuels in early 2005, in November 2005 the DTI announced the UK's own Renewable Transport Fuel Obligation (RTFO) to come into force in 2008**.** The RTFO is modelled on the existing RO in the UK electricity supply industry, and mandates that by 2010, 3.25% (by volume) of transport fuel must come from renewable sources (rising to 5% by 2015). These targets are the amended targets announced in 2008 in response to the findings of the Gallagher review analysis of the indirect impacts of biofuels (RFA, 2008) (see chapter 5). At some point the RTFO will either have to be amended or replaced in order to accommodate the biofuels mandate as set out in the RED (see chapter 5).

4.3.1 The beginnings of the debate

In response to the announcement of the RTFO, in November 2004 the Guardian newspaper published an article describing biofuels as "an

environmental and humanitarian disaster" (Monbiot, 2004). This article was the first to strongly oppose biofuels in a national broadsheet. The focus of the article was on the potential impact that growing crops for energy purposes might have on international food price and the subsequent consequences for the worlds poor (see Box 5 for an overview).

Impacts on society

The first criticisms over biofuels were directed at their potential impact on food supply and food prices. While there is much dispute over the likely impacts of biofuels on both development and food security in poor countries, given the vulnerability of large sections of the global community, this arguably represents the greatest potential impact of bioenergy. It is estimated that around 1.4billion people in developing countries live in extreme poverty (UN, 2008), and that in 2007 more than 900 million people were undernourished; a number that has been steadily increasing (FAO, 2008b). Bioenergy has the potential to impact upon food security in a number of ways. Most obviously, and the issue given most attention, entails direct competition for resources in the case of food crops being diverted for energy production purposes and subsequent rises in commodity costs. However, non-food crops for energy purposes may also compete with food, through competition for land-use and water resources (RFA, 2008), resulting in similar effects (e.g. Rajagopal *et al.*, 2007). A number of issues relating to land-use may also impact on other aspects of human development and therefore impact upon food security (or the ability of individuals to access food) indirectly. These include issues relating to land-tenure rights and the general technologisation of agriculture, which tends to shift power from small producers to large agricultural corporations (UN Energy, 2007). These impacts raise a number of ethical issues relating to distribution of resources and equality.

Box 5. Potential social impacts of biofuels

However, the article also raised the issue of the issue of land use change on the environment, referring to both the potential destruction of forest in SE Asia and Cerrado in S. America through the production oil palm biodiesel and soy diesel respectively (Box 6). At the same time as the RTFO was announced, it was also announced that due to concerns over biofuel standardisation, many small scale producers of biofuels made from waste oil would no longer be eligible for the

20p tax break previously afforded to them. While this received a small amount of media coverage at the time, lack of support for small scale producers using waste is an ongoing issue. While many claim that it represents the most environmentally friendly and responsible way of producing biofuels, it has received little in the way of support from the government, which instead has focused on large scale producers using crops (Jan Cliff, Sundance Renewables. pers. communication).

Potential impacts of biofuels on the environment

It is estimated that about 13 million hectares of the world's forests are lost annually due to deforestation, with Brazil and Indonesia being responsible for 42% and 26% respectively of this net loss in 2005 (FAO 2005). Deforestation in these countries is driven primarily through logging and expansion of soy and palm oil plantations. While the vast majority of these products supply the food, feed and cosmetic industries, there is growing controversy over the role that biofuels might be playing in this expansion (e.g. Earth Policy Institute, 2006; Greenpeace, 2007; Cameron, 2006). In Indonesia at least 19Mha of forest have been earmarked for plantation by provincial governments, while the central government itself has said that there are 27Mha of 'unproductive forest land' available for development (Cameron, 2006). Along with Malaysia, Indonesia hopes to supply a fifth of expected EU biodiesel demand (Tauli-Corpuz and Tamang, 2007; cited in Oxfam, 2008). Thus, although biofuels use only about 1% of current arable land (CE Delft 2008), their marginal effects may be high, particularly if they develop in areas of high conservation value such as the primary forests of SE Asia and the Amazon.

While there may be local environmental benefits associated with increasing perennial energy crops on agricultural land (e.g. Makeschin, 1994; Sage, 1998; Borjesson, 1999; DEFRA, 2003b; DTI, 2004, 2006c), as well as potentially having negative impacts in other areas (i.e. food prices), inelasticity in food markets make the risk of agricultural displacement, with repercussions for biodiversity, GHG emissions and poverty alleviation of serious concern (see section above). Even with technology advances, it is widely accepted that cropland must consume many more millions of hectares of natural habitat to feed a rising world population and its meat consumption (Tilman *et al.*, 2006; CE Delft, 2008). Using FAO statistics, CE Delft (2008) estimates that, even with large increases in average yields (70%), by 2020, rising demand for food and animal feed will require an additional 200-500 million hectares of agricultural land. This compares with current estimated land use for cropland of around 1500 million hectares (FAO, 2008).

Box 6. Potential environmental impacts of bioenergy

As will be more fully explored in the next chapter, much of the controversy surrounding biofuels is not directed at biofuels *per se*. but rather wider issues concerning the governance of their production, trade and use. Specifically it was quickly recognised that the vast majority of demand would be met through imported biomass feedstock and processed fuels. As such, the growth and trade in bioresources for other energy purposes (heat and electricity) is also increasingly coming into controversy. Reflecting the EM discourse, while the RTFO was to include mandatory reporting by producers, there were no binding regulations that either limited where the biofuels came from or what impact they might have. The culture of voluntary agreements with industry and support for best practicable means are social practices that embody the dominant EM discourse, that views these economic interests as 'partners' in a move toward sustainability (see the next chapter, section 5.3, for a more in-depth consideration of voluntary sustainability standards as issues of practice).

2005 represented the beginnings of what was to become in 2007-2008 a very public debate about the sustainability of biofuels. 2005 also saw the creation of the pressure group 'biofuelswatch', set up with the aim of limiting the development of biofuels for transport and the publication of Friends of the Earth's (2005) Oil for Ape Scandal. While focused more broadly on presenting evidence of the impacts of palm-oil production on rainforest destruction in SE Asia, biofuels along with food and cosmetics were identified as the drivers of palm-oil expansion. These claims against biofuels, as well as other issues associated with the likely impacts upon water resources and the likely GHG balances of particular biofuel chains were repeated by a number of other organisations and institutions in 2006 (e.g. Earth Policy Institute, 2006; Cameron, 2006). While debate in the media during this time was focused primarily on the potential impacts of biofuel production on land-use change and food prices, critical debate in academic circles appeared to be primarily focussed on the GHG balances of bioenergy chains using life cycle analysis[3]. While most studies of the time found that bioenergy reduces GHG emissions when compared to the use of fossil fuels (i.e. Elsayed *et al.*, 2003; Farrel *et al.*,

[3] As reflected by journal publications on these issues

2006; CEC, 2006b; Hill *et al.*, 2006), a number of studies started to question the likely GHG of certain chains (e.g. Pimentel and Paztec, 2005). The reaction to the RTFO was intensified by the seeming lack of environmental regulation associated with biofuel supply.

4.3.2 Heating up the debate

2007 witnessed somewhat of a step change in the debate over biofuels, with a ramping up of media coverage (which was increasingly negative) and a number of more 'mainstream' and traditionally more conservative organisations joining the chorus opposing biofuels. Although central government and other supporters pressed (at least rhetorically, e.g. DEFRA, 2007) for an increase of the biofuel target, more and more reports and announcements regarding the potential impacts of biofuel production on food prices, land-use change and GHG emissions were published. This increasingly pitched debate happened against the backdrop of two controversial announcements made in early 2007. The first of these was the proposed announcement to include a mandatory 10% renewable fuels target as part of the forthcoming Renewable Energy Directive (RED). While controversial by itself, this announcement coincided with a perceived victory for car manufacturing lobby groups in opposing legislation that would restrict average carbon emissions from cars to 120g/Kilometre by 2012. While raising the limit to 130g/Kilometre, the European Commission announced it would make up the shortfall by increasing the contribution from biofuels (CEC, 2007). The second controversial announcement came from George Bush as part of his 2007 State of the Union address, in the form of a proposal for a massive corn to ethanol programme[4]. While the announcement of the ethanol programme in the USA might not seem so relevant to the UK, the sheer size of the proposal combined with the emphasis on energy security rather than climate change appeared to have a large impact on the debate in the UK[5].

[4] Available online at: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2007_record&docid=cr23ja07-120

[5] As evident in the amount of press coverage stimulated by this event

2007 and 2008 subsequently saw a number of major publications strongly question the sustainability of biofuels. These included reports from such organisations as the Food and Agricultural Organisation (FAO, 2007; 2008a), the House of Commons Environmental Audit Committee (HoC Environmental Audit Committee, 2008), Joint Research Centre for the United Nations (JRC, 2008), and a number of major NGOs (e.g. Greenpeace, 2007; Oxfam, 2008). Up until this point the use of second generation crops (for both transport fuels and heat and electricity generation) had received little or no critical attention. By avoiding obvious direct competition with food, characteristically being able to be grown on more marginal land and having higher energy yields, second generation technology was (and still is) promoted as a technological solution to the problems facing first generation biofuels. However, while the debate over biofuels is currently still focussed on the use of food crops, in 2007-2008 recognition that while potentially less harmful, second generation crops still represent significant social and environmental threats (i.e. FoE, 2007; RFA, 2008; Farigone *et al.*, 2008; Netherland Environmental Assessment Agency, 2008), means that the debate has shifted somewhat to also consider the impacts second generation crops for bioenergy for heat and electricity (e.g. RFA, 2008).

When finally enacted in early 2009, the European 10% renewable transport fuel target was heavily disputed both within and outside of the European parliament, and disagreement over the extension was a major sticking point in the original RED proposal, with a number of MEP's and organisations calling for a moratorium on biofuel targets (e.g. Oxfam, 2008**;** JRC, 2008; HoC Environmental Audit Committee, 2008; EEA, 2009). The European Joint Research Centre for example concluded that "It is obvious that the cost disadvantage of biofuels is so great with respect to conventional fuels (at least in the mix foreseen in the scenarios analysed), that even in the best of cases, they exceed the value of the external benefits that can be achieved" (JRC, 2008).

Despite an extremely public controversy and the publication of large volumes of evidence as to the potential impacts of over biofuels and internationally traded

bioresources, the UK government has stayed resolutely committed to supporting biofuels nationally and at the EU level. While the government has responded in various contexts to the concerns raised over biofuels (e.g. through the commissioning of the Gallagher review into the indirect impacts of biofuels; see next chapter), it has consistently sought to downplay the importance or relevance of these concerns and has in many instances seemingly just ignored them (i.e. most obviously in the Biomass Strategy; DEFRA, 2007). Within energy policy, bioenergy in all of its forms has been consistently constructed as a fundamentally sustainable group of technologies. As such the UK has vocally supported the extension of the renewable transport fuel target to 10% under the RED.

This support for biofuels raises a number of important questions. The first of these concerns why UK policy on biofuels has remained resolute, despite numerous challenges as to their alleged sustainability? The second concerns why challenges to government policy were so slow to materialise and have been so ineffective? And related to this, the third concerns how biofuels and the increasing globalisation of trade in bio-resource have been discursively supported? The remainder of this chapter will attempt to shed some light on the first two of these questions, while the third is discussed in greater depth in the next chapter.

4.4 Ecological modernisation and biofuels

Given the controversy over biofuels, it is important to ask the questions: Why were biofuels embraced by UK policy in the first place? And, why was support continued throughout the political turmoil of the past few years? In answering the first question, it would be easy to suggest that, in the case of biofuels, the UK was simply responding to pressure from a Europe that had embraced a much more administrative form of ecological modernisation than that operating in the UK. However, this explanation misses some important points; for one it doesn't explain why the UK has been so vocally committed to biofuels and the extension of the renewable fuels target under the RED.

Given that, in terms of cost per KG Carbon saved, liquid fuels are a relatively expensive option for decarbonisation, biofuels appears at first glance like an odd fit with UK energy policy (with its focus on decarbonisation at the lowest cost). However, the support for biofuels in the UK, if nothing else, highlights the multiple drivers of bioenergy policy. While this is discussed in the next section, there is another reasons why European targets for biofuels may have been more palatable in the UK then might at first sight be expected. This concerns the way that responsibility for energy has historically been organised in the UK; with transport falling under the remit of the Department for Transport (DfT) and the rest of energy being overseen by the Department of Climate Change and Energy (DECC) (previously DTI and then BERR). While climate change quickly became a central concern of not just energy policy, but also a range of other policy areas as well, pressure was quickly put on all sectors to 'do there bit'. Given the very sectorial nature of policy making in the UK, much has been made of decarbonisation within sectors/departments. Given the difficulty of decarbonising transport and the lack of options in the transport sector, even under a market orientated or technology blind support mechanism, support for renewable technology in the sector is basically a support for transport biofuels by default.

While rhetorically much emphasis on climate change mitigation and sustainable development as drivers of bioenergy, it is clear that there were and are many other drivers, more or less connected to a wider discourse of ecological modernisation. While it is impossible to untangle the influence of different drivers, with regard to bioenergy the sustainability storyline subsumed a number of powerful interests/storylines regarding among others, security of supply, and the reform of the common agricultural policy. In fact concern over the impacts of internationally traded biomass resources may actually conflict with the way that bioenergy is conceptualised under an energy policy increasingly emphasising the primacy of energy security (as evident in the 2007 energy white paper; DTI, 2007). This is evident in the quote from the 2007 Biomass strategy below (quote 4).

> *4. The use of biomass and other renewables, in place of fossil based fuels, offers the prospect of a more diversified energy mix, elements of which could be sourced from most countries across the world. Energy security continues to be of increasing importance. (DEFRA, 2007; 2.5)*

Scrace and Ockwell (2009), attribute the reemphasis on security in the 2007 energy white paper (published alongside the biomass strategy) as a strategy to rhetorically support a new generation of nuclear power stations. However in the case of bioenergy, it appears that this could well be associated with a drive for a more diversified sourcing of biomaterial. Despite this emphasis on energy security, however, climate change mitigation continues to be explicitly voiced as the major driver of bioenergy, including biofuels, within the dominant discourse. The biomass strategy reiterates the government's aims to bring about a large scale transition to bioenergy integrated within the concept of the biorefinery and bioeconomy (both concepts suggesting an ecological modernising discourse).

Concerning biofuels, the EU's 2005 Biomass Action Plan maintains the importance of maintaining market access conditions for imported bioethanol, and in supporting developing countries that wish to produce biofuels and develop their domestic markets (CEC, 2005). The Commission also recognises that it was in the EU's interest to promote biofuel production globally, as increased consumption of biofuels should act as a tool to exercise downward pressure on oil prices. Published with the aim of promoting biofuels in the EU and developing countries, and preparing for large scale use of biofuels, early 2006 saw the publication of both 'An EU Strategy for Biofuels' (CEC, 2006a) and 'Biofuels in the EU' (Biofuels Research Advisory Council, 2006). One of the aims of the revised strategy represented by these documents was to continue to support the development of an industry led Biofuel Technology Platform, which would formulate recommendations for research in the sector. The other policy areas published in the strategy are: "stimulating demand for biofuels"; "capturing environmental benefits"; "developing production and distribution opportunities"; "extending supplies of feedstock"; and "enhancing trade opportunities and supporting developing countries".

Concerning why the claimed socio-environmental impacts of a globalising trade in biofuels, have had so little impact on UK bioenergy policy, there are a number of explanations. While climate change and energy policy agendas have seemingly, at least rhetorically converged with minimal conflict (Lovell *et al.,* 2009), it is arguable that this has been successful only as far as climate change mitigation has been framed as congruous with the primary goals of economic growth, energy security, and market liberalisation. It is maybe unsurprising then, that concerns over the non-climate impacts of bioenergy have had so little traction. In fact, if one considers the underlying tenets of ecological modernisation, and recognises that the ambiguous use of the sustainable development storyline in the new energy policy may conceal many drivers of biofuels, it may even be argued that the current development of biofuels, with all of its contentions, was inevitable, and from many perspectives, desirable. Biofuels are 'easy', in that they fit in with current practices and socio-technical organisations. More importantly however, they may actively support definition of progress and development underlying the dominant discourse, in terms of opening up new (agricultural) markets and stimulating international trade.

4.5 Why was dissent so slow to materialise?

Another important question to ask, concerns why dissent to biofuels was so slow to materialise (given that negotiations for the 2001 biofuel directive were taking place in the late 1990s). While this question overlaps to a great extent with what will be discussed in the next chapter, regarding how support for bioenergy and biofuels was maintained in the face of vocal opposition, this section will deal with two subjects. The first of these involves the strategically ambiguous use of sustainable development rhetoric in energy policy, and the second examines the preoccupation of the bioenergy community with stimulating the bioheat and electricity sectors.

4.5.1 A storyline of sustainable development

A central argument of this chapter is that support for bioenergy and the new energy policy were engendered in part by the use of a broad storyline of sustainable development, and that the ambiguity of this storyline initially 'captured' many different interests/narratives. It appears that while framed in the language of sustainable development, the dominant discourse around energy issues as represented by mainstream energy policy represents something that many would not recognise as sustainable development. While we will turn to look at competing notions of sustainable development more closely in chapter 5, here we will concentrate on how this ecological modernising discourse utilizes the language of sustainable development

The 2003 energy white paper, *Our Energy Future,* articulates various derivations of sustainability 69 times. As well as sustainable development, sustainability is conjugated as: *sustainable energy policy, sustainable energy services, sustainable communities, eradicating fuel poverty sustainably, sustainable energy economy, sustainable consumption, sustainable energy research, sustainable construction, sustainable rate of economic growth, sustainable residential development,* and *environmental sustainability*. As can be seen, the terms 'sustainability' and 'sustainable development' here are used interchangeably and in a number of different contexts; both as broad contextualising ethic and as narrow measure of sub-system longevity. While recourse to a storyline of sustainable development can be seen to create a sense of operational integrity and inter-textuality within energy policy, it also raises a number of questions regarding the aims of the discourse and also the work that this language of sustainability might be performing. Despite the contested nature of sustainable development as a concept, from a discursive perspective it can be regarded as a 'positional good', raising associations with a number of commonplaces associated with environmental protection, intra- and intergenerational social equality, economic prosperity and quality of life.

A global perspective?

In the new ‘sustainable’ energy policy, the commitment to sustainable development is reinforced through recourse to a 'global perspective' for energy policy and a storyline of international development. By repeatedly stressing the impact that climate change will have on people in developing nations (quote 5), it is also implied that the new ‘sustainable energy policy’ is fundamentally driven by a moral commitment and development agenda.

> *5. Climate change - largely caused by burning fossil fuels - threatens major consequences in the UK and worldwide, most seriously for the poorest countries who are least able to cope." (DTI, 2003, Ministerial forward)*

This apparent concern with the international developmental implications of the UK’s energy consumption however is, as has already been alluded to, constructed on top of a much narrower conception of the problem. By presenting climate change as the primary sustainability issue, a number of other framings and impacts of energy use in the UK are effectively sidelined (e.g. geopolitical impacts of acquiring and maintaining primary energy resources, resource depletion, issues of nuclear waste and proliferation, local air and water pollution). This also has repercussions for the way that bioenergy is conceptualised (as discussed in later sections). As well as being constructed as a moral responsibility, climate change mitigation is also constructed as an economic argument. By conceptualising climate change as a market failure or externality and backing this up with cost-benefit modelling studies, reducing GHG emissions is presented as consistent with the core imperative of maintaining economic growth. It is seen as important to stress that the costs of mitigation do not exceed the costs as modelled (quote 6).

> *6. Most of the carbon savings we are looking at pre-2020 can, we believe, be delivered at costs lower than, or in line with, the illustrative range for damage costs. (ibid., 2.1)*

While discursive linkages are made between different scales of sustainability (e.g. global/local, near term/long term) little attention is paid to the nature, logic or consistency of these connections. Whilst the environmental issue of climate change is portrayed as global and long-term issue (if dislocated from a deeper consideration of its socio-economic contingencies), the immediate social issues to be addressed by the new 'sustainable' energy policy are constructed as local and short-term. However this is done in such a way as to conform to the global sustainable development storyline. The White paper identifies three challenges for energy policy: climate change, declining national supplies, and aging infrastructure. This leads to the primary objectives of: cutting carbon dioxide by 60%, maintaining reliable energy supplies, promoting economic growth through competitive markets, and adequately heating every home. The primacy of economic growth achieved through competitive markets is again reiterated in the three social objectives of energy policy. While market efficiency is portrayed as essential to both maintaining reliable supplies and adequately heating every home (as discussed by Scrace and Ockwell, 2009), it is also constructed as an end in its own right (quote 7). Drawing on the recognisable 'pillars' storyline, the three pillars of sustainable development (environmental, social and economic) are recast into four (quote 8).

> *7. liberalised and competitive markets will continue to be a cornerstone of energy policy. (ibid., 1.20)*

> *8. This white paper is a milestone in energy policy. It is based on the four pillars of the environment, energy reliability, affordable energy for the poorest, and competitive markets for our businesses, industries and households.(ibid., Ministerial forward)*

The role of liberalised, competitive markets in sustainable development is underpinned by a number of assumptions. The first of these is that competitive energy markets lead unproblematically to 'sustainable economic growth' (quote 9) and energy reliability (quote 10). This first statement also implicitly reinforces and naturalises the contested concept of 'sustainable economic growth'. Second, that maintaining reliable (cheap) energy supplies is a priority for

sustainable development (quote 11). Third, that economic growth will lead to increased living standards and quality of life (quote 12), and that living standards by this measure need to be quantitatively (c.f. qualitatively) increased.

> *9. we are determined to promote competitive energy markets, in the UK and beyond. This will help to raise the rate of sustainable economic growth (ibid., 1.18)*

> *10. Competitive markets incentivise suppliers to achieve reliability. For example, suppliers will diversify their own sources to reduce their commercial risks, thus contributing to wider diversity (ibid., 6.6)*

> *11. Reliable energy supplies are an essential element of sustainable development. (ibid., 6.1)*

> *12. higher resource productivity ...will contribute to higher living standards and a better quality of life. (ibid., 1.2)*

Throughout the strategy, current and future energy consumption in the UK is repeatedly constructed as 'needs', thus in the context of sustainable development placing this consumption beyond question. Along with resource consumption, energy consumption is not problematised, apart from where it is wasteful or inefficient. Thus the storyline of consumption as recognised by Lovell *et al.*, (2009) does not appear in the discourse apart from in its technical, efficiency-of-use embodiment.

Our development is their development

Addressing the 'sustainability needs' of UK consumers is further justified by discursively linking our 'needs' with the needs of the developing world. Thus, market liberalisation as a tool for sustainable development is further support by recourse to the traditional development storyline of trickledown economics

(quote 13). Here issues of international development are portrayed as a function of national economic development. This assumption about the knock on effects of market liberalisation and economic growth at home, as well as the association constructed between issues of domestic energy security and sustainable development also gives credibility and legitimacy to the aim of opening up of foreign resource markets (quotes 14 and 15).

> *13. And the opportunity to lead the way, in Europe and internationally, in developing environmentally sustainable, reliable and competitive energy markets that will support economic growth in every part of the world. (ibid., 1.2)*

> *14. We will work internationally to promote regional stability, economic reform, open and competitive markets and appropriate environmental policies in the regions that supply most of the world's oil and gas (ibid., 1.2)*

> *15. [we will] promote liberalisation of energy markets including through the World Trade Organisation (WTO), the IEA and the Energy Charter Treaty (ibid., 6.35)*

On a close reading it is clear that none of the concepts one might naturally associate with sustainable development, such as ecological citizenship, multi-level governance, sustainable consumption, international development as a moral imperative, or lifestyle change are serious components of this discourse. While the development of energy policy practice has revealed many of the commitments underpinning its conceptualisation of sustainable development, the 'dislocation' of sustainability has been strategically used to essentialise bioenergy and biofuels as fundamentally 'sustainable' technologies. While the way that this is achieved will be discussed further in the next chapter, we will now turn attention to another feature of the political history of bioenergy that may help explain the lack of early opposition to biofuels in the UK.

4.5.2 A Focus on heat and electricity

As discussed in the first half of this chapter, the approach taken to decarbonisation under the new sustainable energy policy relies on a number of market based mechanisms aimed to deliver carbon reductions at the lowest possible cost. These mechanisms are therefore designed to be technology neutral (that is they are designed to 'blindly' support the current cheapest RE option). As such, the new 'sustainable energy policy' quickly came under criticism (e.g. Mitchell and Connor, 2004; Mitchell, 2008). Many of these criticisms have been directed at the failure of particular 'market based' approaches to stimulate RE development. For example in 2004, Mitchell and Connor drew attention to the risky and complex nature of the RO, lambasting it for failing to support emerging technologies. Such criticisms were not confined to the period immediately after the publication of the white paper, but represent a long running challenge to the particular approach to decarbonisation taken by the government. While individual mechanisms have been criticised, so has the governments entire approach to RE (Helm, 2007; Mitchell, 2008).

The criticisms over the Governments' approach to RE, while not directed at bioenergy *per se*., nevertheless at this time represent much of the politics over bioenergy development in the UK. Up until 2005, bioenergy appeared to enjoy wide based support, with the majority of politics focussed on how best to stimulate the development of a technology that in many cases has a complex and extended set of actors involved in the production, processing and combustion of biomass. The primary market-led approach to RE in the heat and electricity sectors, quickly led to growth in co-firing of a large amount of imported biomass and little development of local production chains, and other technologies that are perceived as higher risk, have long lead times or are capital intensive (Thornely and Cooper, 2008; Slade *et al.,* 2009). Much of the attention during the first half of the decade was therefore, particularly within the bioenergy community, focused on how to stimulate the development of bioheat and bioelectricity, particular with regard to supporting local supply chains. In particular there was a struggle over the merits of setting targets for specific technologies including bioheat and electricity.

This focus on stimulating non-co-fired bioelectricity and heat, also appeared to marginalise any thorough consideration of biofuels, which by this time already had it' 'own target'. In a special biomass report published in 2004, The Royal Commission for Environmental Pollution set out the potentially strong role of bioenergy in making a significant contribution to the UK's renewable energy portfolio, and made a number of recommendations regarding the removal of regulatory and socio-economic barriers to the development of what is saw as an industry not fulfilling its potential. While thorough in its consideration of bioenergy for electricity production, despite the passing into law of the biofuels directive in 2003, the report did not consider the use of biofuels for transport. This can be viewed as reflecting the prevailing focus the bioenergy community during this period, on the use of bioenergy for heat and electricity production.

In direct response to the earlier RCEP report, in October 2004 the government also commissioned an independent but industry led 'Bioenergy Task Force' to "assist the Government and the biomass industry in optimising the contribution of biomass energy to renewable energy targets and to sustainable farming and forestry and rural objectives" (Bioenergy Task Force, 2005). Published in 2005, the report recognised a number of barriers to deployment of biomass technology and suggested a number policy options to stimulate the growth of the industry. Again however, as in the earlier RCEP report, the use of biofuels for transport was not considered. The most notable recommendation to come from the Task Force, was that of setting independent targets for bioenergy. To this end it noted that, "to ensure progress, Ministers should detail the percentage of energy supply the Government expects will be developed from biomass by 2010 and 2020" (Bioenergy Task Force, 2005). However, despite the request for specific targets for bioelectricity and heat, the government explicitly refrained from committing to binding targets (DTI and DEFRA, 2006).

The debate over the most appropriate support for bioenergy (and RE in general) was also happening in the fallout from the failure of the first large bioenergy demonstration project in the UK to date. Project Arable Biomass Renewable Energy (ARBRE) was a high-tech project designed to demonstrate electricity

generation from dedicated energy crops. It employed high efficiency gasification combined cycle technology while also contributing to the waste management problem of sewage disposal. (Piterou *et al.*, 2008). Having received funding in the early 1990s through the EC's DGXVII Thermie Programme, and the NFFO, in 2002 the project went into liquidation. While, the collapse of the project was ascribed to a combination of failings (Piterou *et al.*, 2008), it appears to have reinforced the more recent perception that the UK bio-energy industry is falling behind that of other European countries (RCEP, 2004; Van der Horst, 2005).

Conclusion

This chapter has argued that the new 'sustainable' energy policy in the UK can be understood to be an effort to implement something like a weak version of ecological modernisation. As such it is maybe unsurprising that a technology such as biofuels that fits so well with existing socio-technical configurations, should find such support. Despite appeals to the moral dimensions of climate change, great effort is also put in to selling of climate change as a market efficiency issue; climate change is thus to be addressed as a matter of economic self-interest. While this basic analysis is not original, it does reveal the way that sustainable development is rhetorically constructed to reflect these priorities. It also suggests that despite the fact that climate change mitigation has been integrated into this agenda, there is very little reason to expect the wider sustainability concerns associated with bioenergy to have much traction within this discourse, especially if they conflict with the primary goals of diversifying energy sources, liberalising trade and opening up foreign markets. Despite an early policy commitment to biofuels in the UK, very little consideration appears top have been given to their potential wider impacts. While to some extent this may be a function of the effectiveness of a very ambiguous sustainable development storyline, it is also likely that the issue was marginalised by the preoccupation of the bioenergy community with attempts to stimulate a national heat and electricity sector under the prevailing market based policy.

Chapter 5 The politics of sustainability

While the previous chapter considered the development of bioenergy under the prevailing energy policy discourse, this chapter takes a closer look at the politics underpinning the debate over the sustainability of bioenergy. In the case of biofuels, it is possible to discern two broad discourse-coalitions. Whereas those who advocate biofuel development tend to coalesce around a number of storylines relating to the primacy of climate change as an environmental issue and the scientific-rational nature of the issue of sustainability, opposition discourse tends to fundamentally challenge these framings. In order to highlight the assumptions underpinning the dominant discourse it is thus seen as important to explore how these various interests have attempted to reframe the debate over bioenergy. As well as extending some of the themes presented in the last chapter, in focussing on the discursive strategies utilised in the debate over biofuels in more detail, this chapter will focus in more detail on a number of other rhetorical devises used in the debate. It will also explore in more detail some examples of discourse as practice. While this chapter will draw quotes from a number of sources, it will attempt where possible to draw examples from speeches made by senior figures at a Westminster Energy and Transport Forum seminar on the 'Future of Biofuels' held in 2008.

5.1 A debate over sustainability

As discussed in the previous chapter, continued support for biofuels by the UK government in the face of growing opposition has led to a polarisation of the debate over biofuels. It is thus now possible to discern two fairly distinct discourse coalitions in the public debate over the sustainability of biofuels. What might be called the pro-biofuel coalition, as well as including central government, also includes a number of industry actors, international bodies such as the IEA, individual scientists, and pro-business NGOs, whereas the anti-biofuels coalition involves a number of humanitarian and environmental NGOs, certain socialist governments, and a number of prominent individual scientists. While these coalitions have coalesced around a number of core

storylines that appeal to a wide range of actors, there are a multitude of perspectives and interests/narratives underpinning the debate. While it is biofuels in the spot light, it is not necessarily biofuels *per se* that are the main site of conflict. It is clear that the current dispute over biofuels extends to much wider issues concerning the globalisation of trade, the technologisation of agriculture, and other issues related to the broad direction of modernisation. Thus, for example, although many different interests 'sign up' to storylines associated with the dominant discourse, they do so with potentially different understandings of these purposefully ambiguous concepts. Despite the very public concerns over biofuels (and now other bioenergy technologies as well), the EU and UK government have stayed committed to expansion of the biofuels sector and the pursuit of minimal criteria based standards for sustainability (see section 5.3).

5.1.1 Sustainable development and biofuels

Under the UK's new 'sustainable' energy policy, bioenergy has been developed, at least rhetorically, in the context of sustainable development. The controversy that has developed over the technology is also framed in this context. Bioenergy is thus explicitly embroiled in a debate over the sustainability of the technology(s). However, although the common framing of bioenergy under a banner of sustainable development may suggest a certain degree of rationality to the debate over bioenergy, sustainable development and sustainability, so often used interchangeably, are inherently contested phenomena. Because bioenergy touches on so many socio-environmental issues, the debate over bioenergy can thus be viewed as representing a much wider debate over the direction of modernity and a political struggle over the very definition of sustainable development. While previously representing an apparent consensus, in the case of bioenergy, sustainability as a storyline is now heavily contested. However, just because concrete policy decisions have 'exposed' divisions over bioenergy does not mean that the storyline of sustainability is not still a powerful discursive tool in the debate over bioenergy.

While some environmental perspectives tend to outrightly reject the use of the sustainability terminology, as is the case with much ecocentric philosophy such as Arne Naess's 'Deep Ecology' (Naess, 1997), other radically differing interpretations draw explicitly from the sustainable development rhetoric. Many different visions of a sustainable society and the means of resolving the 'environment and development' problem thus exist (for useful reviews see, Dobson, 1996; Myerson and Rydin 1996; McManus, 1996; Castro, 2004; Williams and Millington, 2004; Connely, 2007). The literature on sustainable development is vast and critiques of the UN position, as well as alternative interpretations can be found within fields as diverse as conservation biology (i.e. Newton and Freyfogle, 2005), poststructuralism (i.e. Escobar, 1995), economics (i.e. Daly, 1996) and environmental Marxism (i.e. Foster, 2002).

Sustainable development can in this respect be considered an "essentially contested concept" (Jacobs, 1999; Ehrenfeld, 2009). Many (but certainly not all) of the criticisms of the 'mainstream perspective' (i.e. as might characterise the UN or UK position) revolve around the conventional conceptions of 'development' employed, and the watering down of environmental concerns with an emphasis on traditional conceptions of human development. In fact, as discussed in the previous chapter, many would not regard these mainstream perspectives as 'sustainable development' at all, but rather as some form of either ecological modernisation or even 'business as usual'. As discussed in the previous chapter, 'mainstream' conceptualisations/EM as represented by the UK Governments approach to energy policy, articulate development primarily in terms of economic growth, and have attempted to reconcile sustainability with key elements of the dominant neoliberal agenda (e.g. free trade, limited regulation, market mechanisms and conservative fiscal policies), in which business and industry have pre-eminence. In this worldview, the main cause of environmental degradation is poverty and uncertainty, which can be overcome by economic growth, increased education of the developing world and an emphasis on technological fixes for environmental problems (Castro, 2004).

This conceptualisation, however, contrasts radically with what many would see as the underlying causes of unsustainability, and critiques of this position often

stem from the perceived inadequacies and contradictions involved in framing a concept fundamentally defined by socio-environmental relations in economic terms (e.g. Redclift, 1987; Escobar, 1995). Many of these viewpoints are also equally sceptical as to the likelihood and even ability of the free-market economy to deliver long-term environmental protection and social equality. Critics see the reliance on technical fixes to solve what are widely seen as political problems as a key weakness when compared to sustainable development, which is claimed to have political notions of limits and global justice built in, even in its conservative versions. In this way it is argued that "ecological modernisation skirts some of the main challenges ecological problems pose for social democratic thought" (Giddens, 1998).

5.1.2 Ecological modernisation and sustainable development

Whilst ecological modernisation has nothing to say about limits or issues of social justice or equity and their underlying causes, it has also been criticised empirically. Thus attention has been drawn to the fact that despite evidence of widespread ecologically orientated reform (among nation states), there is no evidence that this has affected actual environmental outcomes (Buttel, 2000; York and Rosa, 2003). While ecological modernisation takes a nationalistic perspective, the question of whether ecological modernisation in one country is likely to lead to the export of economic processes with high ecological impact and therefore not contribute to overall global environmental improvement is not addressed (York and Rosa, 2003). The promise of efficiency gains is also seen by some as wildly optimistic, as history has repeatedly suggested that these are usually outstripped by overall increases in consumption (Jeavons, 2001; Alcott, 2005).

Underlying many of the critiques is the assumption that sustainable development inherently recognises that societal development cannot be viewed independently from its natural perquisites; leading to a break in the equivalence between development and economic growth that has traditionally lain at the heart of the consensus on development. This is associated with various calls for

a readdressing of social values and more socially equitable and benign growth (Sachs 1999), or even no-growth (Daly, 1996; Sustainable Development Commission, 2009). There is also growing awareness that claims on intergenerational social justice, equity in gender relations and democratic participation in decision making processes are essential with respect to access to and distribution of natural resources (Becker *et al.,* 1999).

5.1.3 Sustainable development as contested discourse

Rather than a well defined concept, sustainable development and sustainability can thus be conceived of as something akin to a politically contested 'meta-discourse', within which various discourses and interests struggle to institutionalise their specific conception and solution of the environment-development issue. However, while powerful interests will always 'attempt' to 'naturalize or reify such concepts (Foucault, 1973), strict definitions of sustainability can't be considered the norm. Despite this lack of clarity many would argue that the concept is not meaningless. In questioning the institutionalisation of power that underpins unsustainable development, Jacobs (1991) for example, sees the concept as inherently politically radical. Conceptualising sustainability as the viability of socially shaped relationships between society and nature over long periods of time, also suggests that it is not possible to consider social or environmental sustainability in isolation. Rather, sustainability has to be conceptualised in strictly relational terms. There is also a strong argument that sustainable development inherently normalises a fundamentally democratic rationale. The debate over whether ecological modernisation should or shouldn't represent as a strategy for sustainable development, if nothing else, highlights the power of language in social change. However, while there is now widespread conflict over the development and use of bioenergy technologies, the ambiguity surrounding sustainable development and sustainability continue to be useful and effective framings for the dominant discourse and pro-biofuel coalition.

Before getting into the debate in more detail, this chapter will first expand on three core elements of the pro-biofuel coalition. These are the focus on climate change as the primary environmental framing for bioenergy, a technological optimism, and recourse to science as of the primary arbitrator of sustainability. This section will draw its material primarily from the 2007 Biomass Strategy, and statements from central government figures. However, where appropriate, quotes will also be drawn from other sources to demonstrate the breadth of the coalition

5.2 Sustainability and the hegemony of climate change

The most obvious aspect of the pro-biofuels discourse is the recourse to climate change as the primary framing device for discussions over biofuels and bioenergy. Throughout the energy policy literature and in argumentation sustainable is used as synonymous with low carbon. While the use of sustainability in this way marginalises other environmental issues in a passive way, it is also used to actively suppress other framings. For example, though in other contexts agricultural expansion and intensification is often portrayed as one of the primary threats to the environment, within the dominant discourse these other concerns are actively repressed. In the quote taken from the UK bioenergy strategy below (quote 16), discussions over the sustainability of bioenergy are constructed in reference to a global agricultural industry that is assumed to be sustainable.

> *16. Managed well, changes in land use to deliver biomass can also give multiple environmental benefits. To achieve this, biomass production must be at least as sustainable, in terms of its wider environmental impacts, as is now the case for "normal" agricultural production. (DEFRA, 2007; Ministerial forward)*

The exclusive focus on climate change as the only environmental issue associated with energy use, leads to a depoliticisation of the trade offs between bioenergy expansion and its impacts on other aspects of society or the environment. It is assumed that the role bioenergy will play in mitigating climate

change renders any other impact miscible. The focus on climate change acts to 'squeeze out' other environmental issues and is legitimated by a wealth of scientific research and scientific facts on both the existence of anthropogenic climate change and the GHG balances of biofuels. While the particular conception of science

Although the non-climatic impacts of bioenergy are not denied, given the lack of scientific 'proof' of their relevance (due to either lack of research funding, their non-amenability to scientific study, or their complexity and uncertainty) little credence is given to their relevance. While biofuels are considered in the quote below (quote 17) as a developing sector that should be allowed to cause 'minimum' impacts, in other instances (including instances in the same document), this is rephrased as 'minimum practical' impacts.

> *17. We are committed to increasing the level of the planned RTFO beyond 5% after 2010/11, but only if…….biofuels are produced in a sustainable way delivering maximum carbon savings with minimum adverse environmental impacts (DEFRA, 2007; Executive Summary)*

Such is the salience given to climate change that, while in any other environmental context agricultural intensification would be regarded as a major environmental threat, in the context of climate change, increasing intensification for energy use is automatically assumed as acceptable. In much the same way as climate change has been used to reframe nuclear power as an 'environmental technology' (Scrace and Ockwell, 2009), so it has been used to justify agricultural expansion and intensification, once iconic indicators of modernity's unsustainabiltity (quote 18).

> *18. Increases in biomass availability will be achieved through the more efficient utilisation of agricultural land (DEFRA, 2007; 4.7)*

5.3 ‘Realising the potential of bioenergy’

Support for biofuels in energy policy and within the pro-biofuel coalition is characterised by a technologically and politically optimistic discourse that reflects its broadly ecologically modernistic underpinnings. Whilst climate change is constructed as the most urgent of environmental issues, it is also associated with a storyline of ‘potential’ or ‘realising our potential’. That is, climate change is understood as a ‘challenge’ to human endeavour. The discursive underpinnings of this storyline are extremely optimistic, both technologically and in terms of the political achievement. Recourse is made to notions of progress and this progress is naturalised as technological in essence. Bioenergy and in particular biofuels, in this light are ‘opportunities’, and to not act to realise their potential for the benefit of mankind would be to question the ability of humans to overcome adversity and fulfil their destined mastery over their environment. This optimism and moral appeal to ‘realise the potential’ of bioenergy are evident throughout the 2007 biomass strategy, but perhaps become most evident in argumentation and in the defence of biofuels. Also included in the quotes (quotes 19, 20, 21) below are excerpts from speeches from industry sources.

> *19. With such dramatic improvements in sustainability on offer,* ***we would be negligent if we did not seize this opportunity****. (Lord Adonis, Minister of State for Transport. Speaking at Westminster Energy and Transport Forum seminar)*

> *20. I was up at the Shell Thorton technical laboratories in the north of England recently* ***where I met excited scientists*** *who showed me a thick green vial of green algae* ***as the feedstock of the future*** *(Andrew Eddy, Head of UK communications Shell; ibid)*

> *21. We know what the problems are with unsustainable biofuels and if we can split the atom and put a man on the moon, I’m pretty confident we can fix them, it’ll be complex, it’ll take time but it will happen (David Pugh, General manger Sales and Marketing Strategy, Saab GB; ibid)*

Although this rhetoric comes across as melodramatic, it appeals to a particular conceptions of the order of things, and invokes a moral imperative to technological progress. This technological optimism is fed by scientific and technological innovation. Thus when challenged over the unsustainabiltity of particular biofuels, recourse is most often made to the potential of second, third and even forth generation biofuels overcoming these issues. This recourse to notions of progress and human endeavour is associated with assumptions about the naturally co-operative nature of human society. Thus, much of the discourse is based on equally optimistic assumptions as to the 'honest' motivations of the multiple actors involved with, and with interests in, the expansion of a bioenergy industry (quotes 22 and 23).

> *22. However all parts of the UK, in common with other countries across the world, are committed to the development of biomass as an essential sustainable resource. (DEFRA, 2007; Ministerial forward)*

> *23. It takes everyone from the growers to the manufacturers of beauty products and detergents to governments and of course ourselves, fuel suppliers, to work in partnership to make an amend to the current practices. We're an integral part of a growing community of diverse organisations that have come together to understand the issues around biofuels to identify the trade offs and dilemmas to help navigate an intelligent way through them. One example is the Round Table for Sustainable Palm Oil which has probably made the most progress to date. (Andrew Eddy, Head of UK communications Shell. Speaking at Westminster Energy and Transport Forum seminar)*

Appealing to the altruistic motivations of actors is a discursively powerful strategy. While the motivations of industry and business are routinely questioned by NGOs, doing so in the context of something such as bioenergy that is being sold as an environmental solution, is a lot more difficult and hard not to be seen as a personal, politically motivated attack. This appeal to the motivations of the bioenergy sector is thus rarely rebuked and functions effectively at depoliticising this aspect of the debate. This assumption about the 'honest' intentions of industry and other actors with interest in bioenergy however is not shared between all those who ascribe to the other storylines

relating to climate change and maximising potential. Thus showing how differing discursive positions may be supported under broad ambiguous storylines.

5.4 Science and sustainability

A central feature of the debate over biofuels concerns the perceived scientisation/politicisation of the debate. In this regard, the dominant ecological modernising discourse and the pro-biofuel coalition frame the sustainability of biofuels and bioenergy more generally as predominantly a scientific issue. This 'rational' evidence based approach to sustainability can be considered as associated with the 'realising the potential of bioenergy storyline'. That is, it assumes that arbitration on certain practices or technologies should be made in a rational, evidence-based way, with the onus placed on science to prove the unsustainability of certain practices. Recourse to science as the arbitrator of sustainability effectively depoliticises the debate by obscuring the instrumental reasons for arbitration and also excluding other forms of knowledge from the debate. The discourse in this way reifies a number of assumptions as to the validity and legitimacy of certain ways of knowing and limits the debate over sustainability to scientifically knowable phenomena and expert debate.

5.4.1 A recourse to science and rationality

Recourse to science in this way reinforces the perceived pragmatic, reasoned and balanced nature of the discourse, and is embodied in the storyline of 'taking a balanced approach', which involves a rational 'weighing up of the evidence'. Commitment to this strategy relies on many of the features of the discourse so far discussed, including the presumption as to the honest intentions and cooperative nature of actors involved in the production and governance of bioenergy. It also relies on humankind's perceived ability to comprehensively manage its environment, and most importantly a linear view of scientific policy making. The effects of this 'scientisation' are a focussing of the debate over issues of management (means rather than ends) and a concerted deference to

discrepancy over certain facts rather than an engagement with discussions over value preferences. Thus it can be seen to distract from larger problem framings about energy futures and land-use in general, to smaller questions about which bioenergy chains are sustainable and which are not. Thus there is much recourse to the categories of ‘good biofuels’ and ‘bad biofuels’, and emphasis is put on the importance (and therefore focus of the debate) of reducing uncertainty in the science, and scientifically making and proving this distinction. This highlights the more ‘administrative’ side of the discourse, or at least the inclusion of, and usefulness of drawing on, these administrative tropes in argumentation. Thus while the discourse could be primarily conceived of as broadly ecologically modernistic, it also highlights the way that more administrative aspects of the discourse are accommodated. This also allows the debate over the desirability of bioenergy to be abrogated to less challenging issues of management (quote 24).

> *24. The article refers to "intense lobbying from campaigners calling for a moratorium on the use of plant-derived fuels". Sadly this is all too often based on cherry-picking evidence - we actually need rational decision-making based on all the evidence. The Royal Society published a report earlier this year that, like the Gallagher review for the Renewable Fuels Agency published last week and any comprehensive review of biofuels, concluded that biofuels have real potential; but we must ensure the investment is put into the most efficient and sustainable types. (Peter Cotgreave. Director of public affairs at the Royal Society. The Guardian, Wednesday 16 July 2008)*

This quote demonstrates how recourse to a “rational decision making based on all the evidence” resonates with the storyline of ‘realising the potential of bioenergy’. In the constant call for evidence-based rational decision-making, the underlying assumption that the debate over the sustainability of bioenergy can be rationalised is reified. In an attempt to rationalise the debate, the parameters of the debate are necessarily narrowed, and are narrowed to those things that are measured, and those things that can be measured. Thus, if the debate is going to be rational and fact based, firstly it needs to be about something that there are scientific facts about, and about something that can be studied in such

a way. In this ‘rational’ framing, the debate tends to be dominated by well funded, quantifiable issues, such as carbon balances.

The framing of the debate in this way also cedes power to those interests that have the resources and the knowledge to engage in the complexities of this type of scientific debate; as discussed below, this manifests in practice as a division being drawn between experts and lay people, embodied in government practices such as expert consultation. The debate itself is highly technical, relying on a vast amount of scientific knowledge as to the various impacts of bioenergy. A ‘rational’ debate necessarily depoliticises the debate, as it assumes an agreed upon instrumental end (in this case the abatement of climate change using bioenergy, with minimal practical environmental impact). While science never dictates action, what it does do is empower those who draw their authority form science to make those interpretations (Wynne, 1996). A rhetorical commitment to ‘rationality’ and the facts of the debate, allows actors to position those with ‘lesser’ or more uncertain knowledge (e.g. those who argue that bioenergy might lead to increased international food prices) as unscientific, irrational, emotional, or involved in the cherry picking of evidence.

5.4.2 Science based policy as practice: sustainability standards

More than a rhetorical device, the science-based policy approach of the pro-biofuel coalition is also a complicated policy practice which acts to structures arguments and through which power is exercised and interests mediated. As well as functioning at a rhetorical and normative level, scientisation is also deeply embedded in institutional practices, reflecting more broadly the institutionalisation of evidence based policy making and scientisation of risk in environmental policy making more generally (e.g. Liftin, 1994; Jasanoff, 2004). The most obvious area where particular interpretations of science and its relationship with policy have been formalised into practice have been the construction of sustainability standards for biofuels under the RTFO and RED.

In response to the controversy over biofuels, as part of the RTFO, the UK introduced the world's first carbon and sustainability reporting scheme for bioenergy. This includes targets for the proportion of feedstock that meets certain levels of environmental performance and GHG savings. While the Renewable Fuels Agency (the body created to administer the RTFO) has no powers to differentiate between fuels based on these criteria, supply of Renewable Transport Fuel certificates for fuels are conditional on companies supplying this information. Minimum sustainability criteria relating to the direct impacts of biofuels however will be conditional on fuels counting toward the 10% target set out in the Renewable Energy Directive. Failure to comply with the sustainability criteria associated with the RED will not however result in the biofuel being banned, just in its ineligibility for support in the EU or against national targets and renewable energy obligations, such as compulsory targets on greenhouse gas (GHG) emissions. The Directive also initially requires that renewable fuels represent at least a 35% CO2 saving (not including indirect impacts) compared to the fossil fuel it replaces. This will be scaled up to at least 50% in 2017 and 60% in new installations thereafter. Bioenergy sustainability is thus to be regulated by the scientific standardisation of GHG emissions for specific bioenergy chains.

However, one of the primary concerns over bioenergy is its potential impact on indirect land use change (ILUCs; see box 7), and as with other 'difficult' socio-environmental issues, ILUCs are deemed to be too uncertain and complex to include in LCA and the standardisation of lifetime carbon emissions. The inability of science to capture and mitigate the wider risks associated with bioenergy, means that arbitrary boarders are drawn around the sustainability of bioenergy. Those uncertainties that cannot be captured or articulated within acceptable limits of uncertainty are considered as illegitimate with regard to regulation.

Indirect land use changes (ILUCs)

While much initial interest into the impacts of bioenergy production focused on their direct impact on land use change, more recently much more attention has been given to their likely indirect impacts (e.g. RFA, 2008; JRC, 2008). Indirect impacts may occur when biomass used for bioenergy displaces crops grown or traded for other purposes. We have a global agricultural market, and thus many of the impacts of bioenergy may be mediated through the interaction of supply and demand and therefore be much more diffuse and difficult to predict. Thus depending on the elasticity of the relevant food commodity market (in a market situation), or the individual decision of the farmer (in a subsistence situation), it is possible that displacing a field of wheat for energy purposes might just lead to that wheat being grown in another location (possibly in another country), with unknown consequences.

While there maybe elasticities in particular grain markets (although c.f. Morten *et al.*, (2006), who found direct correlations between higher soybean prices and accelerated clearing of Brazilian rainforest), demand for overall food and feed has been shown to be inelastic (Searchinger *et al.*, 2008). Thus, while the local impacts of biomass production might be to some extent controllable (or at least accountable) the indirect effects are not. In the case that the displaced crops lead to expansion into uncultivated habitats, these indirect effects may very well represent the primary social and environmental impacts of bioenergy (Royal Society, 2008; RFA, 2008).

Box 7. The indirect impacts of bioenergy on land use change

ILUC's probably represents the largest impacts of bioenergy (see section 5.4.1). However, while their existence has been recognised since the beginning of the debate over biofuels, due to scientific uncertainty over their impact, they have been excluded from official calculations used to measure the GHG balances of bioenergy and biofuels reported under the RFTO. While Bioenergy is deemed carbon neutral under the RO, support for biofuels is legitimated by recourse to their carbon savings (without ILUC factors). For example, in the Renewable Fuels Agency report on the Renewable Transport Fuel Obligation, 2009/10, it was claimed that biofuels had "resulted in significant carbon savings of 51%

compared to petrol and diesel fuels, making an important contribution to reducing climate change inducing emissions in the transport sector"[6]

This scientisation of risk is also institutionalised in international law within organisation such as the World Trade Organisation (WTO). Under such law, it is necessary to scientifically prove the harm of a commodity, before it is legally possible to regulate its trade. While the wider impacts of bioenergy are not easily quantifiable, it was recognised early on by the UK government that any plan to regulate such issues of where biomass feedstock came from would very likely fall foul of World Trade Organisation rules (E4Tech, ECCM and Imperial College, London; DTI, 2005). Despite much lobbying by those concerned about the impacts of biomass trade on international development, World Trade Organisation rules also meant that extending standards within the RED to include mandatory social criteria would have been illegal. In this way, the organisation acts to give precedence to economic values above all others (Sarawitz, 2004). Rather than questioning the ability of scientific standards to form a reliable basis for regulating the complexity of biofuel sustainability, instead the issue of ILUCs is deemed to be another issue (of uncertainty) to be addressed and researched in the future. As such, the EU will be producing a report on the indirect land use change impacts of biofuels in 2010, and reviewing the sustainability of biofuels in 2014. Policy makers are thus able to maintain authority by managing (scientific) uncertainty and building it in to a programme of future research (Shackley and Wynne, 1996).

Elsewhere there is also considerable effort going into the science and politics of designing suitable sustainability criteria for biofuels and there are a number of national and international initiatives aimed at developing and enacting different standards (e.g. IEA Task 40, The Global Bioenergy Partnership, Roundtable on Sustainable Biofuels, Roundtable on Sustainable Palm oil). The support by the UK government for the Industry led Bioenergy Platform (designed to provide information and analysis for institutional decision making and support), and

[6] RFA (2011). Year Two of the RTFO: Renewable Fuels Agency report on the Renewable Transport Fuel Obligation, 2009/10. Available online at: www.renewablefuelsagengy.gov.uk.

these other initiatives can also be seen as manifestations of the dominant discourses commitment to voluntary agreement, and the divide drawn between experts and economic interests and wider society.

5.4.3 The Gallagher review

A significant event in the debate over biofuels was the commissioning of the Gallagher review (RFA, 2008) into the indirect impacts of biofuels. DEFRA's commissioning of the review in 2007 represented the first tangible reaction by the UK Government to the growing contestation over biofuels. This independent, one year study was commissioned in direct response to two high level journal articles (Crutzen *et al.*, 2007; Searchinger *et al.,* 2008) that had attempted to quantify some of the potential negative impacts of biofuels. The review can be seen as an instance of practice that embodied the dominant discourses science based policy approach and a culture of expert consultation. The conditions under which the Gallagher review was commissioned and the controversy surrounding it give important insights into the legitiamizing role ascribed to independent expert consultation in the dominant discourse. While much of the opposition (and at least the first opposition) to biofuels centred on the potential impacts of biofuel production on biodiversity and local land-tenure rights in SE Asia, this has had seemingly little impact on the dominant discourse and energy policy, and it took the publication of these two high-level science articles to stimulate the review (RFA, 2008).

While set up as an 'independent' review of the scientific evidence, the report, made several political recommendations based on the potential impacts that biofuels might be having on food supply and GHG emissions. One of their primary conclusions was that, while biofuels targets should be lowered and development of the sector slowed down, they should not be abandoned (RFA, 2008). While the review highlighted massive uncertainty over the impacts of ILUCs, it was concluded that "there is a future for a sustainable biofuels" (RFA, 2008). Although the Gallagher review could have called on a moratorium on biofuels, its reasons for not doing so rested on the assumption that "this would

reduce the capacity of the industry to respond to the challenges of transforming its supply chain and investing in advanced technologies" (RFA, 2008).

While the report was designed to function as an independent review of the scientific evidence, it was highly political. It thus made recommendations on policy over biofuels, including the setting of targets. One of the primary functions of the review was to interrogate the research of Crutzen *et al.*, (2007) and Searchinger *et al.* (2008), which both seriously threatened the credibility of biofuels in terms of their perceived wider environmental and social impacts. The Gallagher review put considerable effort into questioning and undermining these two peer reviewed pieces. For example, in concluding its analysis of Crutzen *et al.*, (2007), the review states:

> *25. The paper applies an uncertain approach, questionable assumptions and inappropriate, selective comparisons to reach its conclusions. The review by North Energy concludes that "Whilst the paper by Crutzen et al does seek to address an important matter, namely the magnitude of soil N2O emissions from the cultivation of crops for the production of biofuels, it cannot be regarded as resolving the problems and assisting the objective evaluation of biofuels"*

A number of the criticisms that the review levelled at the paper have since been refuted. While criticising the two papers, the review went on to focus on the considerable uncertainty and complexity surrounding the indirect impacts of biofuels. However, it also went on to make a number of conclusions relating to the potential sustainability of biofuels, and suggesting that support for biofuels should continue. Continued support for biofuels was justified by the UK Government by recourse to the statement made in the report that "A genuinely sustainable industry is possible". The Gallagher reviews treatment of the two peer reviewed articles, as well as its uncritical acceptance of other research, can be viewed as a typical example of boundary work by scientists working in highly politicised science. While the reviews conclusions and analysis were criticised, the involvement in the review of staff working with the UK Home-Grown Cereals Authority's activities promoting the use of cereal crops for

bioethanol production was also questioned.[7] The (scientific) nature of the two articles can been seen as making some form of response from a Government, that draws so much authority from evidence based policy making, necessary. However, it also provides a very obvious example of politicisation of science, as well as the role science can play in depoliticising debates.

The report met with mixed reaction from interested parties, with some industry sources such as the National Farmers Union and the Renewable Energy Agency, decrying the suggested lowering of targets[8], and other environmental and social NGO's claiming the report did not go far enough (e.g. Birdlife *et al.* 2009). In response to a consultation on the RTFO held in response to the Gallagher review, the Secretary of State for Transport made a statement on 28th January 2009 announcing that the Government had decided to introduce legislation lowering the level of the obligation in the short term (this does not affect the long term targets and was above the level suggested by the Gallagher review)[9]. The reviews recommendations as to the potential sustainability of biofuels and the dismissal of calls for a moratorium on biofuels were used as direct justification for this decision. The Gallagher review can be seen as representing a quasi-nonpolitical technical decision over the future of biofuels, and the review served its purpose, without unduly affecting the expansion of the biofuels industry.

5.5 Contested knowledges/ contested frames

It is obvious that current bioenergy development, and in particular the setting of biofuels targets are challenged by a number of different discursive positions. While these include a number of more 'imaginative' discourses, such as stronger versions of sustainable development (Dryzek, 1997), they also contain

[7] Response to the Gallagher review from Paul Crutzen, Arvin Mosier and Keith Smith. Available on line at www.renewablefuelsagency.gov.uk

[8] Comment available at RFA Biofuelsnow website: http://www.biofuelsnow.co.uk/resources.php?page=2

[9] However, this will not affect the mandatory 10% target enacted as part of the RED.

more ‘radical’ green positions, with broader transformative agendas. However, while the dominant discourse around biofuels has been challenged by many different perspectives, and the integrity of any singular discursive stance is hard to ascertain, there appears to be what could be considered a loose anti-biofuel coalition in the debate over biofuels. That is, there are a number of storylines that different actors within the debate have coalesced around, and a number of common features of the discourse.

5.5.1 A poor allocation of resources

Biofuels and trade in biomass for other bioenergy technologies have been challenged on many fronts, including their potential impacts on food prices and availability, impacts on deforestation and land use change, impacts on biodiversity, competition for water resources, and land-tenure issues. A major struggle has thus been attempting to reframe sustainability to be about more than climate change mitigation. However, as discussed in earlier sections, for a number of reasons, the non-climatic impacts of bioenergy have had little traction in energy policy. As such, although much effort has been put into the reframing or broadening of the debate (to include such issues as food security or development), much argumentation has focused on highlighting the inconsistencies in the rationale for biofuels. This can been seen as an example of the dominant discourse structuring the debate in terms of what types of arguments and knowledges are deemed legitimate. While, many of the discursive positions challenging current biofuel practices are not primarily concerned with issues of efficiency, it appears an effective discursive strategy, and as such, least-cost decarbonisation and the efficient utilisation of resources, represents a powerful storyline in resisting the dominant position on biofuels. While there are obviously many drivers of biofuels, it is climate change mitigation that is primarily appealed to in the dominant discourse. As such it is the logic of using biofuels in a least cost decarbonisation argument that receives much of the focus (whether or not least cost decarbonisation is a primary concern for these positions).

One of the most effective challenges to current biofuel policy has involved the use of life cycle analysis in 'proving' the relative expense of biofuels for decarbonising compared to other heat-and-electricity producing bioenergy technologies. First detailed explicitly by the Carbon Trust in their submission to the 2006 energy review, a hierarchy (being a hierarchy it sidesteps many of the disagreements over specific carbon balances and issues with LCA parameterisation) detailing the relative costs of various technology types is now well accepted. According to this argument, if the objective is to reduce carbon emissions at least cost, then it is rational to use bioenergy to decarbonise large proportions of the electricity and heat sectors before using it in the transport sector. Thus, a major inconsistency in the government's support of least cost decarbonisation and biofuel is revealed. Though the expense of biofuels in terms of cost per KG of carbon saved would appear not to be the primary concern of many of those with interests in challenging the development of the biofuel sector, it is nevertheless an effective challenge of the dominant rationale (quote 26).

> *26. Ultimately biofuels represent a poor allocation of resources- biomass or tax payer's money (Robert Bailey, Oxfam; Westminster Energy and Transport Forum seminar.)*

Within the same rationale it is also claimed that much bigger and more efficient gains can be made by reducing transport levels, improving public transport and by investing in fuel efficiency than by promoting biofuels. These inefficiencies and inconsistencies in policy and the dominant discourse are a central component of the anti-biofuels discourse. These are highlighted in the quotes below (quotes 27, 28)

> *27. When there are such glaring failures in other parts of energy policy, it's a bit difficult to take seriously the idea that biofuels is an important part of the answer (Doug Parr, Chief scientist for Greenpeace; ibid.)*

28. The UK will play its role in diluting energy efficiency standards in vehicles over the next few days [Oct 2008] at the European level. (Doug Parr, Chief scientist for Greenpeace; ibid.)

While there are broad concerns with the general scientisation of the debate over bioenergy (as discussed in the next section), it is also the case that competing storylines over bioenergy's role in climate change mitigation are heavily supported by to recourse to contested scientific knowledge. While provided as the primary rationale for bioenergy development, the impacts of different bioenergy chains and technologies on GHG emissions and climate change are complicated and uncertain. Energy derived from biomass is not carbon neutral, and greenhouse gases, such as carbon dioxide, methane, nitrous oxide, and other nitrogen oxides (NO_x) are nearly always emitted during the farming, transportation and manufacturing stages of bioenergy production (Hill *et al.*, 2006). However, it is often the production of the feedstock that has the largest implications for the GHG balances of particular bioenergy chains (Pimentel and Paztec, 2005; Tilman *et al.*, 2006).

Will bioenergy help mitigate climate change?

While the majority of early life cycle analysis (LCA) studies of bioenergy chains have found that bioenergy reduces GHG emissions when compared to the use of fossil fuels (i.e. Elsayed *et al.*, 2003; Farrel *et al.*, 2006; CEC, 2006b; Hill *et al.*, 2006), an increasing number of studies have concluded that once the true costs of farming have been factored in some biofuel chains may represent no GHG savings at all (e.g. Pimentel and Paztec, 2005). However, the radical variation reported in the potential carbon savings brought about by particular chains is testament to the complexity of the modelling process and the uncertainty in our knowledge about certain geomorphological, biological and climatic processes associated with agricultural practices. For example, N_2O has been estimated to have a global warming potential 296 times greater than CO2 (IPCC, 2006). While N_2O is assumed to be one of the main causes of agricultural contributions to climate change (Royal Society, 2008), recently

Crutzen *et al.* (2007) estimated that the accepted rate that nitrogen from fertilizer use is returned to the atmosphere as N_2O (i.e. as set out in IPCC, 2006) may have been underestimated by 3-5 times.

Confounding the finding of much analysis is the fact that many studies do not include carbon emissions from direct or indirect land-use change. As well as needing to account for the direct 'carbon cost' of farming activities, changes in soil carbon content can dramatically influence the carbon balances of bioenergy. While conversion of land, particularly undisturbed land, releases much of the carbon previously stored in plants and soils through decomposition and fire, the loss of forests and grasslands also foregoes the carbon sequestration these plants would have provided in the future (Searchinger *et al.,* 2008). Explicitly taking into account expected carbon losses from soil and vegetation a recent study by Fargione *et al.* (2008) calculated the carbon debts (calculated as the amount of carbon lost to the atmosphere in the first 50 years after land conversion) incurred from the conversion of different land types to bioenergy production. They found that converting US cropland that had been retired under the Conservation Reserve Programme for 15 years into perennial grass for ethanol production created a carbon debt that would take 48 years to repay. The amount of time needed to recover the carbon released when converting tropical peatland rainforest to palm-oil biodiesel production was calculated to be 840 years. Searchinger *et al.* (2008) estimated that under current projections, GHG savings from corn-ethanol would take on average 167 years to pay back carbon emissions resulting from indirect land-use changes occurring in such locations as China, Brazil and the US.

It has been suggested that replacing agricultural land with perennial crops can reduce green house gas emissions by reducing nitrous oxide (NO_2) emissions from fertiliser use (e.g. Borjesson, 1996), and increasing soil carbon as a consequence of consistent inputs of root and shoot litter (Reicosky *et al.,* 1995; Tilman *et al.*, 2006). However, many of the benefits of reduced carbon dioxide emissions from soils and reduced nitrous oxide emissions are not products of energy crop cultivation *per se* and would still be realised if the ground were left fallow. A study by Righelato and Spracklen (2007) estimated that over a 30 year

time period, the creation of permanent forest from cropland has GHG balance consequences that compare favourably with all existing liquid biofuel production technologies. It has thus been concluded that climate benefits can be even greater from converting grassland to permanent forest with no harvest for biomass energy (Field *et al.,* 2007).

It is safe to say that while biofuels are supported by recourse to those studies revealing carbon savings for bioenergy chains, actors challenging the dominant discourse utilise those studies claiming positive GHG emissions. Despite being framed as a scientific issue, this type of uncertainty however, is never likely to be resolved. This is because the uncertainty surrounding bioenergy GHG emissions does not stem primarily from measurement inaccuracy. Rather, it relates to how boundaries and parameters are drawn around relevant systems, which in turn relates to cultural practices of science; what counts as science, and what is credible and legitimate scientific study. In other words it concerns epistemological issues as to the validity of certain knowledge.

5.5.2 Choosing the right biofuels: rejecting the scientisation of sustainability

Despite the differing rationales for opposing biofuels and the differing positions held, there has been much concerted effort to challenge the government's position on biofuels. For example a number of high profile ad campaigns have been run by coalitions of NGOs. Figure 3 depicts an advertising campaign run in UK broadsheets in 2008 jointly by WWF, Friends of the Earth, RSPB and Greenpeace. This emotional public appeal suggests that while much of the argumentation over biofuels consists of the exchange of various facts relating to GHG balances, land-use etc., it is clear that much of the opposition is rooted in the very framing of bioenergy as a technical issue, whose sustainability can best be managed in a scientifically rational way.

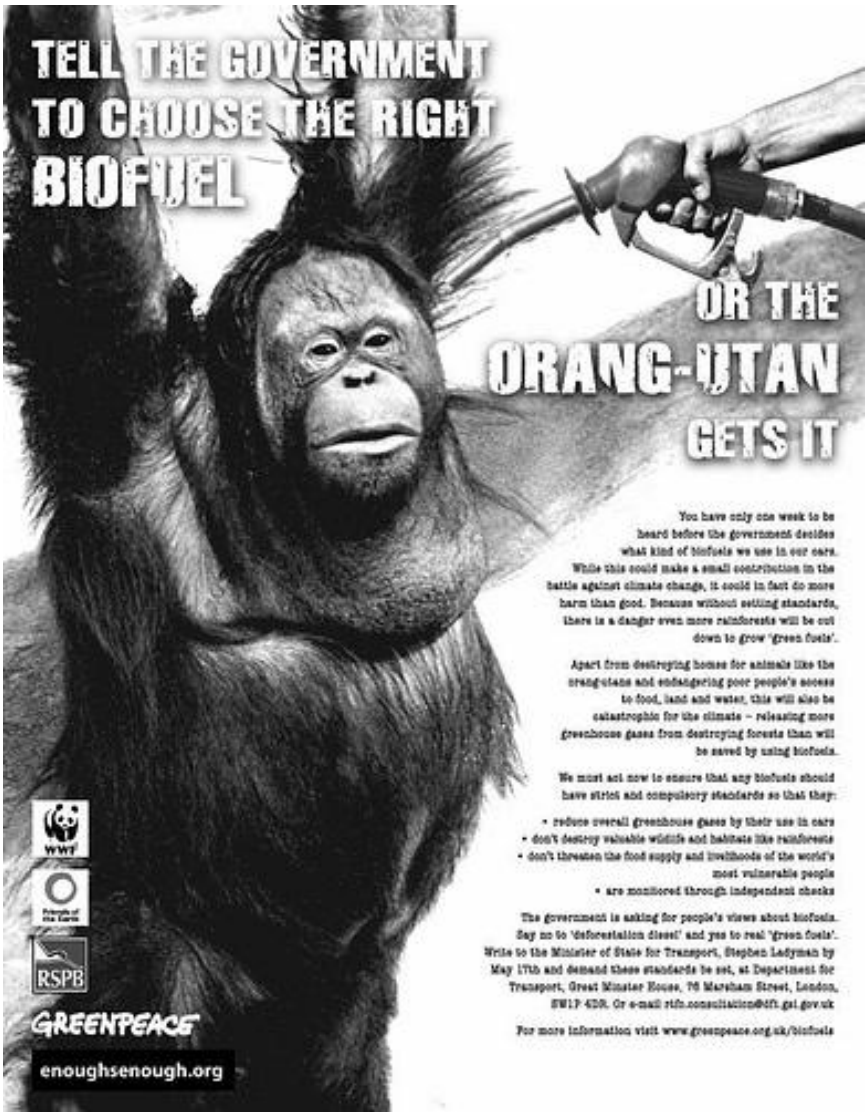

Figure 3. Showing advertising campaign sponsored by a coalition of NGOs against biofuels.

Whether it is possible to design or police a system that would guarantee that bioenergy use saves GHG and neither interferes with food markets, nor leads to environmental destruction, is questioned (e.g. Biofuelswatch, EEA, 2009). Although the debate since 2007 has primarily centred on the potential impacts

of biofuels, it is also important to consider that this is directly linked to the way that bioenergy was being, and was planned to be regulated. While in the UK the RTFO does not differentiate between biofuels, the proposed plan to implement something like a globalised sustainability standard approach to sustainability under the RED was also viewed by many as unachievable and therefore little more than greenwashing. Thus a recognisable storyline within the anti-biofuels coalition is that of choice. That is, sustainability requires more than scientifically constructed sustainability standards, and an active rolling back of neoliberal ideals of free trade and notions of progress.

There are claims that sustainability criteria do not deal with the root causes of the problems of over consumption in developed countries and that guaranteeing sustainability is misleading and might lead to higher consumption (FoE, 2007). Other issues include the feasibility of accounting for the complexities and uncertainties of indirect land use change, the legality of restricting trade under international law regulating free trade, potential for manipulation by embedded political interests, as well as issues of governance and accountability in developing countries without the necessary resources to adequately regulate such a scheme. While most of the challenges are not anti-science (which they are often portrayed to be), they are based in a belief that sustainability is not something that can be managed by a simplistic recourse to scientifically defined standards, under conditions of increasing trade liberalism. Under such conditions satisfactory management is deemed impossible, particularly in the face of powerful actors with interests in circumventing such regulation.

While within the pro-biofuel coalition the sustainability of bioenergy is abrogated as a scientific issue, it is clear that many of the objections to biofuels are based in non-scientific moral discourses, and relate to issues such as trust of corporations and responsibility. In contrast to beliefs held within the pro-biofuel coalition, much of the anti-biofuel discourse is predicated upon belief in a fundamentally interest based and unfair social order. This tends to turn the problem framing from questions of ‘can we do it?’ to questions of ‘should we do it?’ While many ‘anti-biofuels’ positions would, under different circumstances, not reject biofuels altogether, due to the perceived inability and lack of

motivation to properly manage such a system of differentiation between biofuels, many organisations have called for a complete moratorium on biofuels (i.e. Oxfam, 2008**;** JRC, 2008; HoC Environmental Audit Committee, 2008; EEA, 2009)

> *29. What I support is scrapping a 10% biofuels target because I am not convinced that ….we are really going to be able to mange this properly. (Robert Bailey, Oxfam; ibid.)*

However, an interesting point about the advertisement in figure 3 is the use of the framing of 'choosing the right biofuel', as opposed to for example scrapping biofuels altogether. This position seems 'much more reasonable' and 'captures' more support, even if the demands about actively banning imports of certain biofuels made by such groups are never likely to be achievable under current trade law.

5.6 Other discursive framings and rhetorical devices

While the primary struggle over the sustainability of biofuels reflects the assumed ability or desirability to comprehensively manage our environment, and the role that science should play in this endeavour, there are a number of other identifiable discursive framings at work in the debate. Many of the specific assumptions underpinning the framing of bioenergy in the dominant discourse are also challenged, particularly the availability, definition and responsibilities associated with the use of 'marginal' land and the likely positive consequences of increased agricultural technologisation on 3rd world development

5.6.1 We must use everything/ must we?

A discursive strategy used to counter claims that biofuels are an expensive way to decarbonise energy use involves the essentialisation of the transport sector. This recourse to the fact that we 'must use everything available' can be seen as

analogous to the primary storyline of ‘realising the potential’ of bioenergy, and complements the image of heroic struggle discussed earlier. This claim has been used explicitly by the government in rebuking claims to the poor cost effectiveness of biofuels compared to other bioenergy technologies (quote 30).

> *30. One conclusion of this strategy [Biomass Strategy] could be that these incentives should be reordered to reflect this hierarchy of use of biomass. However, such an interpretation would be overly simplistic as it does not take into account the relative importance of biomass fuel sources in delivering climate change goals and targets. For example, despite their higher cost of carbon, transport biofuels are essential to carbon savings in the transport sector for which there are few other options in the short to medium term. (DEFRA, 2007, Executive Summary)*

The essentialisation of the transport sector, as something that must be dealt with separately from the electricity and heat sectors is reinforced by the urgency granted to decarbonisation under the storyline of climate change. While this argument may well reflect the sectorisation of energy between government departments, the view that something must be done in the transport sector is an essential element of the pro-biofuel discourse. The essentialisation of the transport sector is again strengthened by appeal to the primacy of climate mitigation and the subsequent need to act on ‘every front’ (quotes 31, 32, 33).

> *31. We need to explore every avenue for achieving these cuts in emissions in sustainable ways over the decades ahead. (DEFRA, 2007, Executive Summary)*

> *32. The challenge is to use everything at our disposal (Robert Keys MP, Vice chair all-party parliamentary group on Energy. Speaking at Westminster Energy and Transport Forum seminar)*

> *33. We need to do something; this [biofuels] is something we can do today (David Pugh, General manger Sales and Marketing Strategy, Saab GB; ibid.)*

As discussed earlier, in contrast, those positions opposed to biofuels aim to construct the transport sector as just another component of our overall energy system, and highlight the choices that we have, and are necessary to make in moving toward a more sustainable future.

5.6.2 The need for a balanced approach: bioenergy as same

As discussed earlier, the 'realising the potential of bioenergy' storyline utilised by the pro-biofuel coalition is also associated with a storyline of 'taking a rational, balanced approach' to sustainability. While recourse to humanity's heroic and united struggle to combat climate change forms the central component of the pro-biofuel discourse, paradoxically, when defending the use of biofuels a discourse of pragmatism is often invoked. Thus the reliance on science and rationality as lynch pins in the debate over sustainability is encapsulated in the storyline of 'taking balanced approach'; whether it is a balance between biofuels and other technology, between the environment and the economy, or between fuel and food (quotes 34, 35).

> *34. We need to worry about how we mitigate and adapt the use of land in such a way that we deliver the right balance between fuels and food, and that means food security as well (Professor Brian Collins. Chief scientific advisor for DfT and BERR; ibid.)*

> *35. What we need, I think, is a balanced approach. Obviously the industry needs to have confidence that we are proceeding, but equally there is no point in proceeding with this policy at all if it doesn't deliver the sustainability that we seek……..I am very anxious indeed that we establish a solid middle ground on this so that both all of us with concerns about the environment and all of those who are here today who obviously are seeking to develop businesses based in this area, can have confidence that we have a sustainable policy…A genuinely sustainable industry is possible. (Lord Adonis, Minister of State for Transport.; ibid.)*

Balance, while not needing to be explicitly based on any pre-defined rationality, and making a number of assumptions about the value or weighting of phenomena being balanced, emphasises the commitment to compromise and a general rationality. However, it can always be used in defence of a certain technology, and has the same effect as the 'realising the potential' storyline in that it supports a rationale of not choosing between technologies. Quote 36 appeals to the storyline of balance by invoking the well known 'three pillars' storyline of sustainable development, which can be interpreted as calling for a balancing between the environment, the economy and society.

> *36. We at Shell look forward to continuing to play our part in trying to build an industry that balances the social, environmental and economic benefit to society of providing biofuels. (Andrew Eddy, Head of UK communications Shell; ibid.)*

A storyline of seeking to find 'balance' and taking a pragmatic approach, appeals to a sense of rationalism and compromise. It is also supported by the highly scientific nature of the discourse, and the recourse to a considered and rational assessment of bioenergy. Quote 34, also highlights and reinforces an important assumption underpinning the dominant discourse. This is the construction of bioenergy as 'same' rather than 'other'. That is, that it should be viewed as just another crop and judged accordingly. This assumption is also reinforced in the quote below taken from the ministerial forward to the biomass strategy (quote 37).

> *37. Managed well, changes in land use to deliver biomass can also give multiple environmental benefits. To achieve this, biomass production must be at least as sustainable, in terms of its wider environmental impacts, as is now the case for "normal" agricultural production. (DEFRA, 2007; Ministerial forward)*

The counter assumption is that bioenergy is different to other crops such as food crops. That because it is a supplying a human 'want' rather than 'need', and because it is an additional stress on the land, it should be considered differently and have to meet much higher standards. Whilst the dominant

discourse sets out to construct biofuels as 'the same' as other commodities, many of those opposed to biofuels set out to highlight the difference between biofuels and other commodities. Thus the dominant discourse talks about finding balances between food and fuel, and stressing the 'needs' of an oil consuming public. In contrast, much of the opposing discourses frames this consumption as 'wants', and acts to highlight the distinction between food needs and mobility wants. These differences between the discourses are evident in the way data is framed and interpreted within them. For example, while under the dominant discourse it is often stressed that palm oil diesel has a minimal impact on land use change because only 1% of palm oil is used to manufacture biodiesel (the rest being used for food and cosmetics), under opposing discourses it is claimed that oil palm biodiesel has a big impact because this 1% makes up 20% of the increase in oil palm demand. Thus it can be seen that while the dominant discourse acts to constrain debate to the exchange of scientific facts, there are deep underlying value disputes shaping the construction of and perceived relevance of these facts.

5.6.3 Lots of land

The availability of land, its classification and the responsibility associated with its use are all issues that are very much contested in the debate over the sustainability of bioenergy, both for fuels and other applications. Underpinning the dominant pro-biofuels discourse however, it is generally assumed that there is a lot of degraded or marginal land available globally for growing crops for energy purposes (quotes 38, 39).

> *38. At current usage levels biomass can be considered as an untapped resource. (DEFRA, 2007, Executive Summary)*

39. There is a lot of land, we have a very European idea of what big is, when you go to countries like Brazil or Africa you get a very different idea of what big is, it's not what we think big is in Europe, and the future is managing those areas……The future is entirely managerial and it's within the grasp of governments and companies to deliver that future. The money is there, the land is there, the feedstocks are there, it just needs to be managed, and I don't accept that we can't do things sustainably (Andrew Owens, Chief Executive, Greenenergy. Speaking at Westminster Energy and Transport Forum seminar)

Leaving aside the question of whether it is possible to manage where crops for bioenergy are grown for now, one of the issues that has emerged from the debate over bioenergy is disagreement over the scale of the biomass resource that is available globally. The concept of 'potentially available' land for agricultural expansion is extremely complex, and while a number of studies have attempted to assess land resources, the outcomes vary significantly. As well as depending on assumptions about yields, technology learning and demand, there is also serious disagreement over what constitutes 'suitable' land, both in terms of viability for growing crops and the values attributed to that land by local communities, and what will be the future demand from other sectors such as food.

World primary energy use in 2008 was approximately 11295 mtoe (BP, 2009) (or approximately 473 EJ; 1EJ = approx 10^{18} J). Reviewing a number of studies, the International Energy Agency conclude that bioenergy could supply between 200 and 400 EJ (settling on an average of 300 EJ) by 2050 (IEA Bioenergy, 2007). These numbers are based on assumptions of 60 to 100 EJ being generated from marginal land[10] and 0- 700 EJ coming from current agricultural land. These figures are however heavily disputed and represent some very optimistic assumptions regarding yields, food demand and availability and viability of marginal land in some of the models used (i.e. Field *et al.,* 2007). For example, one of the studies used estimate that surplus food supplies in the future could lead to the abandonment of up to 2000 Mha of agricultural land;

[10] N.B. 'Marginal land' is a disputed category. See section 3.1.3. for further explanation

more than the current global cropland area (Hoogwijk *et al.*, 2005). This contrasts with other major international assessments that predict the need to expand agriculture to satisfy future food demand (e.g. FAO, 2008a; CE Delft, 2008). While used to justify the potential of biofuels, the IEA figures demonstrate the way that uncertainty represents an important boundary object for science and policy (Shackley and Wynne, 1996). The range (uncertainty) produced by the IEA represents the result of a number of different deterministic modelling runs rather than a probability range of bioenergy potential resource. Uncertainty is thus transformed from ignorance and indeterminacy within individual models to something more tractable.

In contrast to the IEA assessment, Field *et al.* (2007) estimate that available marginal land represents at most a potentially harvestable energy source of 27 EJ . This is a little more than 5% of the 483 EJ of energy consumed in 2006. The European Environment Agency (EEA) estimates of land suitable for agricultural expansion are lower still, ranging from less than 50 million hectares to approximately 400 million hectares depending on whether natural grassland is included (EEA, 2006). CE Delft (2008) point out that global statistics on idle or degraded agricultural land are incomplete, but estimate that they might only account for around 150 Mha. They thus conclude that, being insufficient even to meet their estimates of additional demand for food and feed (200-500 Mha by 2020) let alone additional bioenergy demand, demand for bioenergy will require additional agricultural land, leading to loss of natural habitat in various regions of the world.

While such uncertainty is used to support both pro- and anti- biofuel positions, the situation is more complex. Thus while land availability is often presented as a scientific issue, much of the uncertainty represents value judgments as to what the term ‘available’ actually means. Framing availability as a scientific issue also acts to marginalise the alternative problem framing that concerns whether production is likely to expand into appropriate areas; an issue at the heart of much anti-biofuel sentiment. A major assumption underpinning the estimates made as to land availability is that second generation crops for

bioenergy will be grown primarily on degraded and marginal lands, therefore avoiding competition with food and biodiversity (e.g. CEC, 2006a).

While definitions of what counts as 'marginal' is often disputed and frequently defined using economic parameters, it has also been argued that these lands are often of both high biodiversity value (e.g. Anderson and Fergusson, 2006) and high carbon content (RFA, 2008) and while not economically productive, of high value to local subsistence farming (FAO, 2008a; FAO, 2008b). For example, while the Indian government has identified 400,000 hectares of wastelands suitable for jatropha plantation, a number of NGOs and academics have contested this classification (e.g. Rajagopal, 2007). It is claimed that locally these lands are largely classified as Common Property Resources (CPRs) and while they may not be 'economically productive' are nevertheless essential to the livelihoods of poor people who use them for food, fuel, and building materials. It is expected that 'marginal' lands are often likely to be worth far more to poor people than their market values reflect (Oxfam, 2008).

While there are disputes over the potential resources available, and the definition of marginality, there is also contention over the likelihood that 'degraded' areas will actually be used in preference to more productive areas. Although many non food crops can be grown on degraded land, the Renewable Fuels Agency (RFA, 2008) concludes that the potential for use of these lands should not be overstated, since whilst many of the proposed crops may be able to grow in difficult conditions, the yield performance may be poor. Marginal or degraded lands are often arid and have low soil fertility. They commonly suffer from vegetation degradation, erosion, salinization, soil compaction, and soil nutrient depletion. Pollution, including alkalization or acidification, and waterlogging may also be associated problems.

Despite the claims made for such crops as jatropha to grow on marginal land, the commercial viability of jatropha on such land has been questioned (ODI, 2008). For example, Naylor *et al.* (2007) question the economic feasibility of developing many of these remote and marginal lands. Economic models indicate that bioenergy and food will directly compete for land area, and that

even modest GHG regulations (US $20/ton carbon tax), alongside the commercialisation of cellulosic ethanol production, could lead agriculture for bioenergy to expand to occupy 1500 Mha by 2050. In this scenario, biomass production displaces significant areas of agricultural lands, and could lead to the more than doubling food prices on the global market (Johansson and Azar, 2007) and subsequent deforestation for agriculture in other parts of the world. (Field *et al.,* 2007).

According to a recent Friends of the Earth report, a number of NGOs in Swaziland have witnessed farmers under contract to a biofuels firm turning over good quality land to jatropha cultivation. This included land that had been used to grow food crops (FoE, 2008). Studies have confirmed that the value of higher yields from good prime agricultural land usually outweighs any additional costs associated with the land. It has therefore been concluded that a strong demand for biofuels would intensify pressure on fertile land where higher returns could be realized (Azar and Larson, 2000 cited in FAO, 2008a). RFA (2008) note that implementing and enforcing policies to target 'appropriate' land represents a significant policy challenge. Increasing the demand for biofuels particularly has already resulted in undisturbed ecosystems in the Americas and SE Asia being converted to biofuel production or crop production (Fargione *et al.*, 2008; HoC Environmental Audit Committee, 2008; EEA, 2009). It is also expected that second generation lignocellulosic crops will if not already doing so, add to this land clearing unless grown on abandoned agricultural land (Fargione *et al.*, 2008; RFA, 2008).

The Gallagher review concluded that, in the absence of policies that direct agricultural expansion to specific areas this trend will continue, with both high quality agricultural lands and tropical rainforest and peatland at risk (RFA, 2008). This applies both to the growing of traditional crops for biofuels and non-food crops for bioenergy in general. However, given that half of the potentially available land is in just seven nations, many of which are suffering from conflict with little or no control internally over much of their land (THEMBA Technology, 2008), there are questions over the potential to do this.

5.6.4 A driver of (un)development

The assumption of there being lots of available abandoned and marginal land for bioenergy expansion, underpins another assumption within the pro-biofuel position. That is, that bioenergy will be a driver of development, driving forward the professionalization of agriculture worldwide, creating much needed jobs. While development is not a primary driver of energy policy in the UK, this storyline speaks to the dominant neoliberal ideal of globalisation. It also however is ambiguous enough to subsume a number of positions with interests in development. While there are many disputes over the role of bioenergy in development, it is a complex issue. It is thus easy for both sides to draw on examples of instances of positive impacts on local communities as well as negative impacts. As well as relying on the assumption of 'excess' land, it also rests on uncertainty as to the impacts of bioenergy on food prices.

Between 2005 and 2008, food prices rose by an estimated 83% (World Bank, 2008). Rising prices have led to food riots in several countries and the banning of exports of grain and other food commodities (Mitchell, 2008b). However, disaggregating the impact of bioenergy on recent rises in the price of agricultural commodities is inherently difficult and the subject of much controversy. For example, while the US government recently claimed that biofuels have contributed less than 3% to the current food-price rises (United States Department for Agriculture, 2008), attributing primary responsibility to changing diets in Asia, a recent World Bank Report puts the figure at closer to 75% (Mitchell, 2008b). This report concluded that biofuels had distorted food markets through both direct competition for commodities and land, and through encouraging financial speculation in grains. While drawing on the more conservative estimates, in argumentation pro-biofuel position also highlight the uncertainty surrounding the estimates of the impact of biofuels on food prices. Drawing on this uncertainty highlights the discourses assumptions regarding the role of science in policy. That is, that the onus should be on (scientific) proof of harm, rather than on taking a more precautionary approach.

It is often proposed that rising agricultural prices will benefit rural and developing economies (e.g. CEC, 2006a; CEC, 2008b). This position is however challenged by a number of organisations (e.g. FoE, 2007; Oxfam, 2008). While argument for biofuels claim that higher prices are good for people in rural areas, (e.g. CEC 2008b), Oxfam (2008) note that most rural poor are net consumers of food rather than net producers, so like urban poor are also worse off when prices rise. Rajagopal *et al.* (2007) also question who would likely benefit from price increases, raising the suggestion that extra profits are most likely to be captured by a small number of land owners. The potential impact of bioenergy on development extends further than just a consideration of price impacts. While land access is seen as a fundamental condition in realising the potential role of agriculture in poverty reduction, it is also claimed that increasing bioenergy will lead to the disempowerment of the poor through concentration of interests in the agri-business sector and further control of the worlds agriculture by a small number of corporations (UN Energy, 2007; FoE, 2008). In Indonesia and Malaysia the palm-oil sector has been linked to land conflict issues (Oxfam, 2008; Cotula *et al.*, 2008). It is also claimed that, due to higher investment needs and technologisation, the development of second generation crops could further exacerbate the disempowerment of small producers (FoE, 2008). As can be seen, the question of development, while fought with scientific facts, is again underpinned by very different assumptions and values. The presentation of evidence reflects a number of underlying assumptions over the root causes of poverty and value judgments concerning issues of justice and equity.

Conclusion

This chapter has described the emergence of two discourse coalitions built around the desirability of legally binding targets for biofuels in the UK. While the pro-biofuel coalition reflects much of the underlying ecologically modernistic discourse seen in mainstream energy policy, it also appeals to a broad range of other actors. The coalition hinges on two ambiguous but related storylines, that of ‘realising the potential of bioenergy’, and the rational-scientific storyline of

‘taking a balanced approach’. These may possibly be seen to broadly reflect different underlying discourses focussed on more promethean ideals of progress and more management centred ideals respectively. The storylines are highly optimistic and are built on implicit assumptions concerning the linear nature of scientific policy making and the nature of progress and modernity.

The dominant position is challenged on a number of issues. However, while underpinned by very different values and assumptions, argumentation appears to be constrained by the general scientisation of the debate. Whilst the dominant discourse around bioenergy frames the sustainability of bioenergy as a rational-scientific issue, this framing is contested. The effects of this ‘scientisation’ are a focussing of the debate over issues of management and a concerted deference to discrepancy over certain facts rather than an engagement with wider issues. However, it is clear that the production of more science is not making the debate any clearer, nor is it resolving the underlying tensions in the debate. While science is not making debate any clearer, its use in argumentation acts to marginalise alternative framings. The primary effect of the dominant discourse is its effect on what counts as acceptable knowledge. Despite the very technical nature of much of the debate over bioenergy, it is clear that much of the struggle is over the fundamental framing of the debate.

Chapter 6 Researching bioenergy

> *Cheap, sustainable energy could be growing all round us (EPSRC bioenergy webpage; Title)*

While the previous two chapters set out the parameters of the debate over the sustainability of bioenergy, this chapter explores the way that UK publically funded bioenergy research has engaged with this debate, and what discursive positions the projects in question empower? It does this by examining the way that the projects have engaged with the debate over the sustainability of bioenergy, both in the broad way in which the projects have interpreted sustainability in setting their research objectives and agendas, and in the way that bioenergy and sustainability are constructed in project communications. This chapter therefore can be seen as primarily taking a very broad look at the question of 'what' it is that bioenergy science does. While the chapter also explores the way that these framings relate to individual narratives, much of the analysis asking 'why?' is the focus of the proceeding chapters. While the projects of interest were introduced in chapter 3, this chapter begins with a more generalised analysis of their function, scope, and overarching aims.

6.1 The projects

The broad focus of the Research-Council initiatives reflects to some extent the changing political situation surrounding bioenergy in the UK. Thus, while SUPERGEN-Bioenergy is primarily engineering based, and focused around overcoming technical barriers to bioenergy deployment, being funded 2-3 years later, TSEC-BIOSYS and UKERC's focus was broader. While much more explicitly focused on whole-systems approaches and the consideration of bioenergy as part of the wider energy mix, these projects arguably focussed more attention on the social and environmental aspects of bioenergy. In terms of disciplinary breadth, TSEC-BIOSYS is arguably the most diverse of the bioenergy projects and as such carried out research into bioenergy from many different perspectives. While TSEC-BIOSYS and UKERC included more natural

scientists and policy analysts in interdisciplinary bioenergy research, funded in 2006, RELU-Biomass was explicitly led by a sociological research group. Identifying individuals working on the different projects was difficult for a number of reasons. Published lists were often incomplete, and the status of personnel (postdoctoral researcher, postgraduate researcher, technician, etc.) who had worked on the projects was difficult to discern. However, through personal communication and document review a reasonably accurate picture of disciplinary competence was achieved (Table 3). The numbers should not be considered to necessarily reflect the project membership, but rather are a subjective estimate with the exclusion of certain individuals on the basis of involvement with the project.

Discipline	SGEN 1	SGEN 2	TSEC-BIOSYS	RELU
Engineering or engineering based science	17	17	3	0
Engineering/ technology appraisal	1	3	7	0
Agronomy/Biology	7	9	10	3
Environmental science/ ecology	0	0	3	5
Economics	0	1	1	1
Policy analysis	0	0	6	0
Sociology	0	2	0	5

Table 3. Showing the indicative disciplinary spread on the projects

The disciplinary spread on the TSEC--BOSYS project was much wider than in the SUPERGEN consortium, but also a lot more difficult to account for, as a number of individuals could themselves be described as interdisciplinary, and therefore not easily ascribed to a single disciplinary category. While this was true for individuals it was also true for the function of these individuals within the project. As such, the author's allocation of individuals to categories in the table

should be seen as indicative rather than completely accurate. A major difference between RELU-Biomass and the other initiatives is the focus of RELU on interdisciplinarity as an explicit goal of the programme. As well as aiming to generate knowledge on issues of rural economics and land-use, the programme also explicitly aims to build interdisciplinary capacity in the UK research community. It therefore mandates that all projects funded through it be interdisciplinary across the natural and social sciences.

Despite the different disciplinary make ups of the projects and their varying objects of study, there are a number of similarities between them in terms of their overarching focus and aims. Thus, all of the initiatives are focused on to more or less of a degree on the forwarding of the bioenergy sector under a rationale of least cost decarbonisation. While (apart from RELU-Biomass) they are all explicitly concerned with bioenergy in general, the focus in all of the initiatives is on bioenergy for heat and electricity rather than biofuels. And finally, where biofuels are specifically included, the national focus of all of the initiatives foregoes most considerations of the (social and environmental) conditions of their production. Given that the position these projects hold in terms of representing the vast majority of research in to the impacts and sustainability issues associated with bioenergy, as well as reflecting the work of the individual initiatives, it is possible to draw some conclusions in relation to the bioenergy research landscape as well.

6.1.1 A national focus

While theoretically concerned with bioenergy in its entirety, the first phase of SUPERGEN-Bioenergy focused almost exclusively on the use of biomass for electricity production. However, Phase 2 (the funding for which started in 2007) has been expanded to include transport fuels and renewable chemicals within the context of the biorefinery. Theme 6 has conducted a resource assessment, which looked at the potential sustainability impacts for 27 different bioenergy chains and is also conducting a small amount of qualitative research on the production conditions of Argentinean soya diesel. However, while only

potentially representing a small fraction of the research effort, there is still some tension over the extent to which issues with overseas production and trade should be a focus for the research in phase 2 (SUPERGEN-Bioenergy member pers. com).

While TSEC-BIOSYS and UKERC are both explicitly involved with bioenergy in general, they both take an explicitly national focus. While the modelling exercises include supply of biomass from outside of the UK, research into the environmental and social implications of bioenergy, is almost exclusively restricted to impacts within the UK. Thus, while the initiatives conducted work looking at a range of technologies including biofuels, the focus was primarily on second generation crops for electricity and heat generation. An exception to this being the work of one PhD student funded through TSEC-BIOSYS, who was looking at international supply. While the project included a biofuel as one of its three 'case study' chains, within TSEC-BIOSYS the focus was primarily bioelectricity and heat (quote 40).

> *40. TSEC does include the whole range of bioenergy crops including liquid transport fuels, and fair enough, good work needs to be done on the life cycle of these, but the main focus is on the biomass crops. Bioethanol and biodiesel were, oh gosh we'd better include them as well…So I hope TSEC can have a rational look at, at least biomass crops for the UK and look at the possible places that they could be grown and the limitations to those and the factors that would cause you to decide whether it was a good idea to grow them here or there (TSEC-BIOSYS member involved in writing the original proposal)*

Given that RELU-Biomass is explicitly only concerned with production of crops within the UK, it thus appears that while the potential research landscape is large, it is precisely the areas of primary sustainability concern to many (such as large scale land use change, indirect impacts, interaction with and impact upon other commodity markets and trade, international development, technologisation of agriculture) that appear not to be being researched. Nowhere is bioenergy situated within its broader context of global land use change. This point was raised by one of the interviewees commenting on UK bioenergy research in general (quote 41)

41. It almost seems like refusing to look at parts of the picture [research into bioenergy]. We're not going to think about that because that's out of the UK system boundaries. You know, you do have impacts overseas and recognition of that is growing I think. It's not good enough to just look at consumption of products within the UK, you have to think about the production side of things as well. (SUPERGEN-Bioenergy member, C)

6.1.2 Delivering a low carbon energy sector; sustainability as low carbon

While the three energy programme initiatives were all engaged in conducting a wide range of research into socio-environmental aspects of bioenergy, it was the role of bioenergy in climate change mitigation, and in particular least cost decarbonisation on which all of the initiatives were primarily focused. Sustainability of bioenergy within these initiatives was primarily conceived of as synonymous with low carbon. The majority of work within the SUPERGEN consortium is thus concerned with technology development in the context of increasing the economic or technological efficiency of production and consumption. In 2006 UKERC began work on its 2050 project, designed to look at energy futures using least cost optimisation modelling. Within this project the sustainability of the energy system is defined by scenarios based on lowering carbon emissions and increasing energy system resilience (primarily through diversification of the energy system). Under this least cost approach the principle characteristic of sustainability is measured in cost per KG of carbon saved. Apart from a limited consideration of 'public buy in' modelled scenarios run as part of the 2050 project, most work on the sustainability implications of bioenergy has focused on the use of LCA of GHG emissions.

In disciplinary terms, TSEC-BIOSYS probably represents the most diverse of the projects. While engaged in a wide range of research however, the project was arguably also concerned primarily with the decarbonisation of the energy system, through the promotion of (or removing barriers to) bioenergy. The project is thus dominated by least-cost optimisation modelling, supply and

demand modelling and life cycle assessment. While research was also carried out into, for example, the impacts of perennial crops on biodiversity, and social acceptance of bioenergy, concern with carbon balances and economics dominate the project (quote 42).

> *42. Well the overarching theme for bioenergy is green-house-gas mitigation potential. So if we have that as our overarching theme, everything can feed into that, because you can put a carbon cost on everything, so it's really about counting the carbon and making sure we are sustainable at the level of carbon, and I know that's a very sort of techy answer because it's not about society or social coherence, but that's where I'm at in making really biological systems sustainable, linked to industry. (TSEC-BIOSYS member D)*

The only project to conceive of sustainability more broadly at the project level was RELU-Biomass. However, as already discussed, RELU-Biomass's focus on energy crops in the UK explicitly sidesteps many of the more pressing concerns surrounding bioenergy development. The focus of the three energy programme projects on climate change mitigation and least cost decarbonisation was also evident in individual responses to questions about what sustainability meant to them. Despite the varying views on bioenergy (discussed further in 6.2), individual interpretation and use of the sustainability concept in the context of the project were in many respects much more homogenous. Sustainability was in a lot of cases used primarily as synonymous with carbon abatement, renewability and technological efficiency (quotes 43-46).

> *43. I suppose the area that comes closest in SuperGEN to grappling with that issue [sustainable development] will be theme 6…where we've been trying to quantify the best we can the sustainability, in a strict LCA type approach. What is the carbon footprint, what is the cost per KG of Co2 emissions saved? (SUPERGEN-Bioenergy member O)*

> *44. I suppose my view is that any activity that uses our resources more efficiently or reduces our reliance on finite resources is a more sustainable. So if you go to a natural gas fired power plant from a*

coal fired power plant then the efficiency may go from say 30% to 50-55%; that is a positive improvement, so it is sustainable. (SUPERGEN-Bioenergy member P)

45. I don't really think about these things too hard [sustainability]. Its about doing things that don't deplete resources and become more difficult to do, so you can carry on doing them for at least a very long period of time and so energy cropping in theory is more sustainable than fossil fuels because fossil fuels are going to run out, In theory yet we can always grow energy crops. So energy cropping is just per. se. is more sustainable than using fossil fuels. (RELU-Biomass member Q)

46. most of the research elements I can think about there is a sustainability factor to account for, in how efficient you are …… Sustainability is how efficient you can do it (TSEC-BIOSYS member R)

While many individuals talked about the relative sustainability merits of bioenergy, others used the term as a more definitive characteristic of bioenergy. In these cases, any bioenergy technology that lowers GHG emissions, or uses resources more efficiently is considered as de facto, sustainable (quotes 47 and 48). Whilst these quotes show the often narrow way in which sustainability as a concept was conceptualised within the context of the projects, this should not however be confused with an individual's worldview or values.

47. we can look at the fact that for bioelectricity we will get a 90% reduction in carbon if we switch to biomass and that's great. And to argue that that isn't sustainable would be nonsense. You know, that must be sustainable. (Senior academic involved in socio-environmental assessment theme)

48. I would say that the crops we are growing are a sustainable technology, because they are renewable, they recycle their own resources. (RELU-Biomass member S)

In general it was assumed that the way in which these project would contribute to sustainable development is through forwarding an efficient, low carbon bioenergy industry (either through the development of technology or through the removal of social and economic barriers to technology deployment). While the projects all conducted research into a number of other issues associated with bioenergy such as local biodiversity and hydrology impacts of second generation crops, these were often seen by many as secondary concerns, or something that needed to be managed in relation to the primary concern. Unlike the other projects, being focused on the construction of a sustainability appraisal (SA), within RELU-Biomass there has been a lot more resources and time put into discussions of sustainability. While research is being carried out into a number of aspects of energy crop production, it is all being done in the context of the public engagement exercises designed to formulate criteria for the SA. Sustainability is therefore generally conceptualised in a broader way within RELU-Biomass. However, having the project explicitly limited to a consideration of second generation crops in the UK, the project avoids many of the more contentious issues over biofuels.

6.1.3 Forwarding bioenergy

As well as focussing on least cost decarbonisation as a measure of sustainability, all of the research initiatives apart from RELU-biomass, are also, to more or less of a degree, involved in the promotion of bioenergy. That is, while concerned with assessing the various impacts of bioenergy, they are primarily focussed on stimulating the development of the bioenergy sector. This is most explicit within SUPERGEN-Bioenergy. SUPERGEN-Bioenergy is explicitly focused around the forwarding of the bioenergy industry in the UK and as such there is a strong focus on partnership with industry. SUPERGEN-Bioenergy has a number of industrial partners which are involved as ‘equal partners’. Within the networking function of the project, the consortium has been active in the establishment of a ‘Biomass research forum’, intended to engage industry with the setting of bioenergy research priorities. The two key objectives of SUPERGEN-Bioenergy are:

1. To build closer and more effective bridges between the emerging bioenergy industrial sector and the wide ranging academic research so that rapid implementation and commercial exploitation can take place.
2. To provide a well qualified pool of high quality expertise to service the bioenergy sector.

Although not as explicitly committed to forwarding the industry, like SUPERGEN-Bioenergy, TSEC- BIOSYS is also primarily concerned with 'mobilising the long term potential of bioenergy' to UK energy supply. Thus, the aims of TSEC-BIOSYS are primarily to "Identify bottlenecks and suggest measures relevant to technology and policy innovation, stakeholder involvement and bioenergy development" and "Determine technological, industrial, institutional, and policy innovation requirements for an 'optimal' development of bioenergy"[11]. While the aims of the project are couched in less 'direct' language, development of the bioenergy industry is still the primary rationale of the project. This is demonstrated in the quotes below (quotes 49 and 50)

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> *49. The main priority aims [of the project] I think were to get answers which will be useful in particularly policy sector on why is it that the bioenergy sector hasn't developed in the UK? Or what needs to be done to get it to develop (TSEC-BIOSYS theme leader, G)*

> *50. You know but we have this target for the UK of 350K Hectares or up to 1M hectares, at the moment we have less than 10K hectares; this industry isn't happening, so we have to make it more efficient, we've got to have higher yielding crops. These second generation crops that have a better energy balance are undomesticated, we've never improved them. We have to use modern biotechnology to get the yields up. (TSEC-BIOSYS theme leader, D)*

[11] Taken from the TSEC-BIOSYS website.

Whilst UKERC is not explicitly involved in the promotion of bioenergy, the focus on decarbonisation and security of supply reinforce these framings as the most appropriate for considering the sustainability of bioenergy. UKERC is in the business of advocating renewable energy, and as such, bioenergy is thus promoted, by default, as a solution to these issues. This commitment to bioenergy and biofuels in particular are also evident in the construction of bioenergy on the initiatives website (discussed in depth in the next section).

6.2 Communicating bioenergy

While programmes of scientific research can be expected to impact on society materialistically through the production of new technologies and the legitimisation of knowledge for their regulation, they can also be influential in more subtly shaping the way society conceives of and engages with contentious issues at a socio-political level. As was previously discussed in chapter 2, when we move beyond the boundaries of science, rhetoric is powerfully evident in both covert and explicit debates and in the more subtle construction of priorities, management issues, and diffusion of what counts as 'knowledge'. However, mapping out the ways that scientists interact with wider society in the context of their research is complex for a number of reasons. First, being such large projects, interaction takes place at multiple levels and at various levels of formality. Second, the way that individuals engage with non-academics can happen within more or less of a context of the project of interest. Thus, in this respect the project itself is not a bounded phenomenon, and ascribing individual interaction as in the context of the project or not is not clear cut. The case projects have all engaged with a wide range of stakeholders and publics in a number of different ways.

While all the projects engaged with various stakeholders as part of organised research-orientated public engagement exercises, these were primarily designed to attain information on stakeholder views on different aspects of bioenergy. However, the initiatives also contextualise their research to wider publics in a number of other ways. The SUPERGEN-Bioenergy consortium, for

example, also produced a biannual newsletter, intended to be circulated “as widely as possible through the UK and to key players and decision makers overseas” (which as of February 2008 was also co-sponsored by TSEC-BIOSYS and UKERC). As well as describing ongoing research within the projects, the newsletter also provides a platform for industry and other organisations involved with bioenergy. UKERC has also published a number of analysis documents aimed at a wider audience than just an academic one. As well as publishing a ‘Bioenergy roadmap’, it has published analysis with broader remit including a final report on its integrated project, UKERC 2050 and a number of other publications associated with the Technology policy assessment function. While having no formalised dissemination activities, within TSEC-BIOSYS, one member of the project has appeared on television and radio in the specific context of the project.

In terms of interaction with non-academics, the RELU-Biomass project is quite different to the other projects. While a broad range of stakeholder were engaged in setting the agenda for the funding programme itself, the project is premised upon the creation of a stakeholder built sustainability appraisal. This involved two large open meetings which were used to construct the criteria for the model. While protocols to aid the dissemination of project results are built into the RELU funding structure, the project plans to disseminate the final results through its website, through large open meetings and the publication of a booklet and pamphlet. As well as publishing in academic journals, results will also be published in widely read magazines such as that produced by the Royal Society for the Protection of Birds. However, apart from RELU-Biomass there were no plans to disseminate more widely the projects findings. While certain members of the projects interacted with civil servants through more or less informal associations, within the projects there were also no formal links with policy makers (quotes 51 and 52).

> *51. UKERC is having exactly the same problem [as TSEC-BIOSYS] that they have a problem of connection with policy makers. (TSEC-BIOSYS member, E)*

52. what we're doing is rather stand alone in some respects….My impression is that it's been more within its own world, rather than being especially outward looking. (TSEC-BIOSYS member F)

Apart from the project website, it would appear that the primary route for information flow between the projects and specific stakeholders, such as policy makers, was through informal associations between individuals and the involvement of specific individuals in activities exterior to the project. Apart from future dissemination plans planned under the RELU-Biomass project, and the SUPERGEN newsletter, the project websites would appear to be the primary way in which the research initiatives contextualise their research to wider non-technical audiences. If the role of public communication of science is to help put research into a socially relevant context, then the project websites, as the primary way in which these projects communicated their research to wider audiences, have the potential to actively contribute to the public presentation of new social representations (Cheney and Lair, 2005).

The importance of the websites was confirmed by members of the individual projects. Project members generally viewed the websites as important mediums for communicating the context of their work to a wider audience. However, while the websites were seen as important mediums for communicating with wider audiences, individual views of the function and content of the websites varied. Thus while some saw the sites as functioning to inform a general public about the role of the individual projects or initiatives, others saw the intended audience as more technical, citing industry and policy makers as the primary audiences. While the websites were maintained by the projects, generally knowledge as to their content was poor. Thus, while interviewees nearly all viewed the websites as important in terms of communicating the context of their research to non-academic, many of them were unaware of the actual content of the sites. The next section therefore takes a close analysis of the way that bioenergy is presented on the project websites.

6.2.1 Constructing sustainable development

Despite the extremely varied personal views on bioenergy and sustainability existing within the specific projects, the on-line resources all reproduce a similar narrative on bioenergy. All the project web-pages are constructed in a broadly similar fashion; bioenergy is firstly contextualised as part of a particular socio-political reality, and then after this the aims of the projects are introduced. While the websites serve many functions, one common objective is to provide legitimacy for the projects and the research. In this respect all of the projects are involved in constructing particular notions of sustainable development.

Although none of the websites spend time specifically defining what they mean by sustainability, all of the projects endeavour to construct a very broad notion of sustainability. While only the SUPERGEN programme refers directly to the Bruntland report (quote 53), all of the projects draw on storylines consistent with such an interpretation. Thus, while TSEC-BIOSYS is involved in "whole systems" research, all of the projects draw on the recognisable 'three pillars of sustainable development' storyline in setting out their research as being concerned with the environmental, social and economic aspects of bioenergy.

> *53. What do we mean by 'sustainable'?*
>
> *The 1987 UN Report 'Our Common Future', also known as the 'Brundtland Report' stated that sustainable development was:*
>
> *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs."(SUPERGEN Brochure)*

As was discussed in the previous chapter, sustainable development can be considered a positional good, and constructing a broad notion of sustainability acts to raise associations with a number of commonplaces associated with environmental protection, intra- and intergenerational social equality, economic prosperity and quality of life. While all of the projects are primarily concerned with modern bioenergy in a UK context, in contextualising their research, both the UKERC and TSEC-BIOSYS stress an international dimension. UKERC for

example reproduces a storyline of development with the claim as to the likely positive impacts of biofuels on development (quote 54).

> *54. The expansion of biofuel plantations has the potential to improve rural development and therefore the livelihood of the farmers. It is likely that issues related to degraded or contaminated land can be minimised by the establishment of biofuel plantations, as many second generation crops can not only be grown on land unsuitable for traditional food crops, but some even have phytoremediation properties (UKERC website).*

While the TSEC-BIOSYS and UKERC web-pages do not refer directly to any specific philosophy of sustainability, they do allude to notions of development and intragenerational equity in their explicit references to world bioenergy use. While the quotes below (55 and 56) do not make any false or contested claims about bioenergy, they do contribute to a number of discursive objectives, including the construction of a broad conceptualisation of sustainable development, within which the project research can be understood. The UKERC quote forms the opening paragraph of the web page.

> *55. It has been estimated that some two billion people rely on biomass for primary energy of cooking and space heating. This is mostly in the developing countries of Africa, Asia and Latin America, and wood fuels account for some 14 % of global primary energy (FAO, 2007).(TSEC-BIOSYS website)*

> *56. it's a little known fact that biomass constitutes the largest source of renewable energy across Europe. On a global scale 50-60% of the energy in developing countries of Asia, and 70-90% of the energy in developing countries in Africa comes from wood or biomass, and half the world cooks with wood. Despite this, in the UK, energy generated from biomass has remained stubbornly small, only contributing 1.5 % of electricity production and 1 % of heat." (UKERC) (UKERC website)*

In the UKERC case, the presentation of the numerical data is such as to maximize the perceived contribution of bioenergy to world energy supply (i.e. Africa and most of Asia uses relatively little energy compared to Europe and the

USA, while renewable energy use in Europe is relatively low). Reinforcing the centrality of bioenergy to world energy security, this statement not only highlights the global importance of bioenergy as a topic for research, but also, by highlighting the dependency of the developing world on bioenergy, suggests that the development of bioenergy and the UKERC and TSEC-BIOSYS research is at least partly driven by an international development agenda. By suggesting that the objectives of this programme of research may be concerned with social equity, a broader context of sustainability is reinforced by providing a non-committal social dimension to the conceptualization of sustainability constructed elsewhere in the text.

The above quotes also act in eliding the development of modern bioenergy, by association with more traditional energy practices and more natural and harmonic modes of living. On the UKERC website, this ambiguous use of language concerning bioenergy technologies is juxtaposed with the specific problem-focus of the project; that of development of the bioenergy sector in the UK. Although the widespread use of wood for cooking and heating in developing countries would seem to be strange justification for the development of a modern bioenergy sector in the UK, a less critical reading produces a sense that the UK is trailing the rest of the world in energy policy.

6.2.2 Sustainable development as an issue of management

While presenting a broad conception of sustainability as politically or morally motivated ideal, sustainability is also presented as local phenomenon or actual characteristic of bioenergy technology, thus presenting sustainability as quantifiable and fully amenable to closure through scientific research. While recognizable notions of sustainable development are drawn on, in claiming to be able to “examine the sustainability of SRC willow and miscanthus” (RELU-biomass) or “ensure energy production is sustainable” (SUPERGEN-Bioenergy) the websites also construct a particularly managerial interpretation of sustainable development. This strategically ambiguous use of the sustainability concept acts to discursively connect bioenergy and the research on these

projects to the wider ethical and political goals of a Bruntland type sustainable development. While RELU and SUPERGEN both claim to be able to assess or ensure the sustainability of bioenergy systems, TSEC-BIOSYS goes further, characterising energy crop derived bioenergy to be inherently sustainable (quote 57).

> *57. Bioenergy from crops is a renewable and sustainable source of energy (TSEC-BIOSYS)*

In associating the projects with sustainable development, UKERC further refines the concept of sustainability, referring to an 'environmental sustainability' as separable from the social aspects of a more general sustainability. This demarcation of sustainabilities allows association of the concept with what would seem to be a primarily natural-science based endeavour. In claiming to be able to assess the main social, economic and environmental implications of bioenergy (apart from UKERC), and setting the entire endeavour in a context of sustainability, the projects appear to present the issues associated with the technology as primarily managerial (as opposed to political) in nature. Sustainability in this context would seem to suggest parity with minimum environmental cost, and would appear more synonymous with 'enduring for some length of time' than with relating to sustainable development; a position clarified by a statement on the RELU web-page (quote 58).

> *58. It is important to understand the impacts of changing land use to biomass crops in order to optimise the gains and minimise any potential downsides. (RELU-Biomass)*

6.2.3 Bioenergy

This managerial approach to what would appear, through its discursive framing, to be a minimally controversial technology, is supported by the particular socio-political context in which the bioenergy is portrayed to exist. While it should be re-iterated that none of the claims made within the websites could be

considered false, they all reproduce a very positive, uncontroversial understanding of bioenergy in the context of sustainable development. While all of the projects, apart from RELU-Biomass, discuss bioenergy in all of its forms, bioenergy within these project communications is presented as both socially beneficial, inevitably and necessary. The controversy surrounding many aspects of the technologies is also minimised. One way that this is achieved is through recourse to multiple claims as to the benefits of bioenergy, while avoiding the mention of any of the controversies surrounding potential costs or impacts. Thus, while all of the projects appeal to discourses of climate change, energy security and rural development to support the case for bioenergy, it is only UKERC that sets out the potential controversy over impacts. However, while UKERC has a webpage dedicated to 'the food versus fuel debate', little credence is given to these impacts (the next section considers this web page in more detail).

As well as focussing on the potential multiple benefits of bioenergy, all of the websites also aim to also minimise controversy over particular issues. Thus while RELU-Biomass makes the claim that energy crop derived energy is carbon neutral on its website, SUPERGEN-Bioenergy and TSEC-BIOSYS also minimise the controversy over the carbon balance of bioenergy through claims to their low carbon nature with no discussion over the controversy over these claims. Similarly, UKERC also refers to the potential yields associated with second generation crops (quote 59), instead of any description of average or likely yields (RCEP, 2004 uses an estimate of about 10 oven dried tonnes per hectare).

> *59. These crops may achieve phenomenal yields in ideal conditions producing in excess of 30 oven dried tonnes per hectare per year – close to the theoretical optimum (UKERC website)*

6.2.4 The food versus fuel debate

While the introduction to bioenergy within the other three websites is fairly brief, UKERC has a webpage dedicated specifically to the 'food versus fuel debate'. Given that this webpage was produced in direct response to criticism over biofuels (particularly their impact on food prices), it is interesting in that it is involved in argumentation, in terms of responding to the claims made against biofuels. Thus, while much of the project websites focus on presenting the positive implications of bioenergy and not referring to the potential downsides, this page focuses specifically on these issues. In argumentation, this page provides much more insight into the discourse underpinning the presentation of bioenergy in the previous section. The webpage covers a number of different themes and responds either explicitly or implicitly to a number of different accusations made against biofuels. This section will now explore some of these. While many of the opinions on the web-page were also held and reproduced by members of the various projects, much of the discourse was also in conflict with the views of project members.

6.2.5 Jatropha

Jatropha has received much attention in the academic literature and media, both positive and optimistic, and precautionary and negative. As with the other web pages only the potential benefits of this crop are described. Credibility is reinforced in the quote below and throughout the webpage by deference to a number of exterior sources (quote 60). However, here it is also worth noting that while reference to the Food and Agricultural Organisation is made in support of biofuels, this organisation has also been very critical of Jatropha.

> *60. Jatropha is able to grow successfully on marginal land. Such potential is recognised by the Food and Agriculture Organisation of the United Nations (FAO), and they recommend that rural areas incorporate agroforestry into their regular farming practices. Intercropping food with energy crops as well as effective crop rotation increases land productivity and land use efficiency, often resulting in*

not only an improved rural economy but also an increase in food production. This does not only relate to small-scale production of biofuels, as BP are investing in Jatropha as a major source of biodiesel in the future, with plans to grow it on degraded, unused cropland as well as to intercrop it with other currently farmed crops such as mangos. (UKERC Food versus Fuel webpage)

While this excerpt portrays a very positive role for Jatropha, it minimises much of the controversy both over the framing of the issues and over the specific claims made. It also makes reference again to the development role played by biofuels. Despite the claims made for such crops as Jatropha to grow on marginal land, the commercial viability of jatropha on such land has been questioned (ODI, 2008). According to a recent Friends of the Earth report, a number of NGOs in Swaziland have witnessed farmers under contract to a biofuels firm turning over good quality land to jatropha cultivation, including land that had previously been used to grow food crops (FoE, 2008). Other studies have also concluded that the value of higher yields from good prime agricultural land usually outweighs any additional costs associated with the land, and that a strong demand for biofuels would intensify pressure on fertile land where higher returns could be realized (Azar and Larson, 2000 cited in FAO, 2008). Thus the quote from the UKERC website can be contrasted with the viewpoint of one of the TSEC-BIOSYS members (quote 61).

*61. If you can use genuinely marginal land to produce energy crops, this is ***** argument with Jatropha of course, you could then in principle produce energy crops and not impinge on food production, and people like *******….well ****** argues that there is still huge scope for efficiency improvements in agriculture particularly in Africa and probably is right, but I would argue is that until those efficiencies have actually materialised, and as long as Mugabe's in power there not going to, then it's crazy to start thinking in a time of food shortage about producing energy crops. And the Jatropha story, well Ethiopia is a good example; what happened in Ethiopia was Sun biofuels got some land grants to plant Jatropha on marginal land; found very rapidly that the yields were so low it wasn't worth doing and immediately moved on to agricultural land. Same is happening in southern India, which is why some of the Indian agencies are trying to squelch Jatropha before the market builds up. In times of food*

*shortage, if you have higher prices for energy crops rather than food crops, clearly you are going to make it worse. My argument to ****** is "fine, when these marvellous gains in agricultural efficiency have materialised, then we cane come back to it but until then no". (TSEC-BIOSYS member J)*

These two quotes above represent two very different understandings or Jatropha. While the UKERC quote could be described as optimistic and idealised, ascribing to many of the assumptions underpinning the storylines associated with the pro-biofuel coalition, the second quote could be described as negative and precautionary. The UKERC quote also bases its analysis on the implicit assumption of benign commercial interests and the explicit assumption that land use efficiency and economic return are the primary metric of interest in biofuel expansion. Much of this degraded or marginal land in these countries is used for subsistence farming or has a number of other non-economic uses and community value. The second quote on the other hand is based on the assumption of that commercial interests are likely to led to exploitation, and that the risks of food shortage dictates a certain responsibility toward our use of biofuels.

6.2.6 Palm oil

The use of palm-oil to biodiesel is one of the most criticised of biofuels and was probably responsible for the emergence of the debate in the UK. The quote below (quote 62) makes a number of claims and also uses a number of discursive strategies to present palm oil biodiesel as a benign technology.

62. One crop which is frequently criticised is oil palm, as it is grown in tropical regions and so irresponsible expansion would lead to destruction of land with high ecological value, such as rainforests. However, it is important to realise that 80% of total palm oil produced is used for food, with the remaining 20% used in a broad range of non-food industries, including soaps, cosmetics, lubricants, plastics and biofuels, among numerous other industrial processes and products (Palm Oil Facts). It is therefore estimated that biofuels represent only 1% of the palm oil industry, and so is a very minor

driver in, holding limited influence regarding the development and expansion of the palm oil industry. (The food versus fuel debate, UKERC website)

The first of these strategies is the use of the adjective 'irresponsible'. Claiming that irresponsible expansion of oil palm is problematic automatically implies the existence of a 'responsible' expansion which is acceptable. While in many parts of the web page the bioenergy industry is constructed as responsible and committed to sustainable biofuel production, this 'irresponsible expansion' is also constructed as anomalous and not the norm. The rest of the quote attempts to put the accusations against palm oil 'into perspective'. It does this by implicitly categorising the use of oil palm for biofuels as the same as the use of oil palm for food (rather than categorising it as 'other' and therefore not amenable to consideration under the same rationale as that for oil-palm for food). It also makes the presumption that because biofuels only represents 1% of the palm oil industry it necessarily has only limited influence on the expansion of the palm oil industry.

All of the above assumptions are either explicitly or implicitly (in the framings they take) challenged by anti-biofuel narratives. Thus there are many that see any further expansion of agriculture as undesirable, and also who would question definitions of 'responsible' under this discourse. Likewise there are other discourses that would categorise the use of palm-oil for western nation 'wants' (fuel) as categorically different from the use of palm-oil for developing country needs (food), and therefore not directly comparable. The premise made in the above statement regarding the impact of biofuels on expansion of the industry is also challenged. It being claimed that although biofuels only represents 1% of current palm-oil production, it actually represents 20% of marginal land demand, and therefore is very important in the expansion of the sector (FAO, 2008a).

6.2.7 Development, management and the role of industry

A central tenet of the discourse represented by the websites is the desirability and achievability of managing and controlling the environment. The websites in this way present a very 'administrative' discourse. This is linked to a technological optimism and an inevitability concerning technological progress. The excerpt below again draws on the development storyline and makes reference to the opportunities created by biofuels and the potential for them in stimulating international rural development. In reference to the necessity of international standards on biofuel production it also makes a more implicit assumption about the feasibility of global regulation of the industry (quote 63).

> *63. The biofuel industry provides an opportunity for rural communities to rely less on imported fuel and manage land more efficiently, creating jobs and stimulating self-sufficiency and independence, whilst contributing to global efforts to mitigate climate change, but all of this must be managed in an appropriate way with necessary international standards on biofuel production, ensure both environmental and social responsibility. (The food versus fuel debate, UKERC website)*

While support for bioenergy in many ways rests upon the predication that it is possible to regulate such an industry (although perceptions as what counts as good or necessary degrees of regulation will vary), the feasibility and desirability of such regulation are heavily disputed. The quote below (64) from one of the project members draws attention to two primary challenges to biofuel accreditation. First, the complexity and hence technical difficulty in such an endeavour, and second, the political difficulty of enforcing any regulation. This quote again highlights the assumption underpinning much anti-biofuel discourse; that human society is fundamentally underpinned by conflicting interests and that there is little reason to expect commercial interests to be congruent with those of society.

> *64. I can't see how it will be done. I had this discussion with people in TSEC last week and the farmers came back to me and said "no no no no, we can do this…we get accredited for everything." …they say*

that every country in the world does, .. we all get audited and we all keep records, and I just can't see that this is going to be the same from the sort of countries we are looking at. Let's take what we think is an easy one, let's take carbon balances…which you would think the engineers can work out and can all agree a methodology for doing it. But that methodology requires what land was used for in the past, it requires knowing the carbon that's locked up in the soil already, the condition of it. I don't believe you can get that sort of information back reliably from the outposts where this stuff is actually being grown. I have audited UK plants on behalf of OFGEM for biomass, and some of the things you uncover there were pretty grim. That people had very strategically managed to hide. Now if you're busy in South America employing child labour and everything else, you'll be doing a damn better job of hiding it than these guys were for some of their financial creativity. It will be very easy to hide, it will be an absolute nightmare to police and will cost a fortune to police. (Project member)

The quote above can also be juxtaposed with the quote from the website below (quote 65). This excerpt makes explicit the claim as to the honest intentions and motivations of all actors in the biofuel sector. It also makes the claim that all of the issues that have been raised against biofuels are being 'thoroughly' addressed.

65. environmental, social and economic sustainability issues relating to the production of biofuel crops, including oil palm, and the growth of production the demand for biofuels might invoke, are being thoroughly addressed at national, regional and global levels (RSB; RSPO; IEA-Bioenergy). The means by which the biofuel industry has developed should therefore be viewed as constructive: in the manner by which it constantly addresses and improves unfavourable techniques and processes. (The food versus fuel debate, UKERC website)

This interpretation of the role of the RSB, RSPO and IEA-Bioenergy is controversial. Both the industry led Round Table on Sustainable Biofuels and the Round Table on Sustainable Palm Oil (RSB, RSPO) have been heavily criticised by a wide range of environmental and humanitarian NGO's, as being

set up specifically to legitimize a fundamentally unsustainable industry[12]. The IEA has also come under criticism for its extremely optimistic projections of land resources for biofuel crops (i.e. Field *et al.,* 2007).

It is clear that, the UKERC website in particular, reproduces many of the storylines used by the pro-biofuel coalition. It is also clear that the sustainability storyline is used in ambiguous ways to appeal to a broad range of interests. What is obvious here is the intertextuality the concept of sustainable development provides with UK energy policy. However, as alluded to, despite the very particular construction of bioenergy found in the project websites, individual perceptions of bioenergy and the role of science in sustainability are more varied. While the websites were maintained by the individual projects, there are interesting questions raised in regard to their authorship. Despite the seeming importance placed on the websites by project members, it appear that websites are controlled by a small number of individuals. The possible reasons for the seeming lack of concern among other project members as to their content, is explored more fully in the next chapter. This chapter now concludes with an exploration of individual narratives of bioenergy forwarded by members of the research initiatives.

6.3 Narratives on the sustainability of bioenergy

Despite the very particular portrayal of bioenergy and sustainability on the project websites, opinions of individuals within the projects varied. For example, while some individuals saw a rapid expansion of first generation biofuels as an urgent necessity, others desired a complete reversal of biofuel policy. Trust in industry as delivers of sustainability was also in contrast with the view of industry as part of the problem. These views are reflective of very different understandings of sustainability and very different discursive commitments.

[12] See FoE online at: http://www.foei.org/en/media/archive/2009/certified-palm-oil-not-a-solution Greenpeace online at: http://www.greenpeace.org.uk/blog/climate/first-certified-palm-oil-shipment-just-bit-public-relations-lubrication-20081118

While many interviewees saw us as land constrained, other spoke of vast tracts of available land; while some saw an ever tightening food supply, others dismissed food shortages as a short-term blip. These differing opinions contrast with the very definite projections of the websites and are now explored. The very different outlooks are contrasted effectively in the two quotes below, both from senior scientists working on the TSEC-BIOSYS project (quotes 66 and 67).

> *66. If you think about the impacts of diverting food crops in to fuel, it seem to me as night follows day, it's blindingly obvious and I cant understand why people can't see it, but anyway it seems to be quite obvious that demand for food is hardly likely to decrease, so you'll need to grow more total material. Now there's two ways to do that. Ones to go more intensive, more fertilizer more irrigation and we're going to have to do that anyway to increase food production anyway. The other way is to get more land. How do you get more land? You clear land that is in semi-natural vegetation now. There is a little buffer. There is a little buffer…I think there maybe some abandoned agricultural land in the former Soviet Union, maybe in Brazil, Argentina…that's not going to solve things and as far as big companies are concerned it's cheaper to cut down forest in Indonesia. So that's what is happening and is going to happen, so this is just crazy. (TSEC-BIOSYS member, I)*

> *67. A lot of people dismiss the first generation technologies as being something that will simply pass and that's partly in the name and that's a mistake because the first generation technologies are still going to be highly appropriate ways of making biofuels for the next hundred years or so, and some of those production chains are actually highly efficient in terms of GHG balances against petro-chemicals. Organisations like the house of commons environmental audit committee who came out fairly strongly against biofuels or at least suggested that there should be a significant delay before moving forward on implementation or mandating have got the picture only partially correct in my view, they have, delay is not really a sensible option at the moment, I think that if we are generally heading toward abrupt climate change, we can't simply not have biofuels and have a business as usual case, which is fundamentally dependant on fossil oil. (TSEC-BIOSYS member, L)*

While much of the consternation was over biofuels technology and centred on arguments of efficiency and actual GHG savings, as shown in quote 66 above, rejection of biofuels as a technology also stemmed from more fundamental disagreements over land use in general. While much of the discussions about the negative impacts of bioenergy took place in the context of biofuels, land use arguments against biofuels by extension are also applicable to other bioenergy technologies. The individual represented by the quote below was talking about second generation (willow and miscanthus) in the UK, predominantly in the context of its use for heat and electricity production (quote 68).

> *68. And now that they've got this thing about food shortage, then well maybe it's a good thing that we [in the UK] didn't go into huge areas of biomass cropping 5 years ago. When we had set-aside it seamed rather stupid just to have set-aside. (RELU member)*

However, despite the above quote, there was a general consensus throughout the projects regarding the desirability of increasing domestic supply of bioenergy through the growing of second generation crops for heat and electricity purposes. The perceived extent to which bioenergy could/should contribute to the UK's energy needs, and support for biofuels in particular, was often associated with recourse or not of a number of the assumptions. Thus a number of issues, including the essentialisation of the transport sector, the availability of land, food supply, and trust in industry were disputed. These assumptions are briefly explored below under their respective headings.

6.3.1 The essentialisation of the transport sector

As described in chapter 5, support for biofuels is often associated with recourse to a storyline of taking a pragmatic approach to impending and catastrophic climate change. Within this discourse there is an assumed responsibility to be tackling climate change on all possible fronts, including the use of biofuels for transport. While the first two quotes below (quotes 69 and 70) reproduce this assumption, the third one (quote 71) challenges it.

69. In terms of road transport fuels, it's pretty much the only option we've got to decarbonise road transport over the next 20 years (TSEC-BIOSY member L)

70. I think there needs to be a move away from electrical generation from biomass, certainly biomass derived in the UK. There are other RE technologies. If you look at road transport, air transport, everything, transport fuels, there aren't. Hydrogen, I think it's still someway off. I think in the shorter term, the best thing we can do is to derive transport fuels from crops. (SUPERGEN-Bioenergy member M)

71. You look at where energy is used in the UK, it's used for space and water heating primarily, so it's bloody obvious what you ought to be doing with the biological material isn't it. And I think the reason that one gets lost is the way things are fractured between different government departments. (TSEC-BIOSYS member J)

As already mentioned, views on the desirability of biofuels were mixed. However, whatever ones view of biofuel, most interviewees saw heat and electricity as the ideal way of producing bioenergy, and this was primarily associated with a storyline of technological efficiency (rather than the economic efficiency so evident in the dominant discourse explored in chapter 4). While the individual quoted above was categorically against biofuels, most other individuals made recourse to much more positive discourse, and while some were opposed to the use of first generation fuels, were optimistic about second and third generation technologies and the efficiencies associated with these.

6.3.2 The availability of land

Another assumption underpinning the very positive opinions of the potential of bioenergy is the existence of large amounts of unused land globally. While there have been various attempts to model this land availability (as discussed in chapter 5) there is little agreement. While there is much disagreement about the value or use of land categorised by institutions such as the IEA as 'marginal',

projection to 2020 and beyond are also based on assumptions about future food demand and technological advances. The two quotes below highlight some of the more optimistic perspectives (quotes 72 and 73).

> *72. even when you look at the very conservative numbers there, there's a huge amount [of land] available that you could use for biofuels, that is considered to be suitable in terms of, you know, it's not terribly ecologically valuable at present (SUPERGEN-Bioenergy member B)*

> *73. We use less than 1% of global biomass for cultivation at the moment, so there is a vast resource. We have to use it effectively and efficiently (TSEC-BIOSYS member D)*

Other respondents challenged this perspective. Although in quote 66, in the previous section, these claims are directly challenged in terms of a disagreement over land availability, more commonly the framing of the above position was instead challenged. The two quotes directly above assume a very managerial tone, and implicitly assume the ability of us to manage such resources. They can be contrasted with quote 61 which instead frames the issue as one of likelihoods of use rather than maximum potential land available.

6.3.3 Trust

It appears that much of the differences between individual narratives were associated with issues of trust. While some respondents were untrusting of the motivation or ability of commercial interests to lead a sustainable expansion of the bioenergy sector, many either didn't question the motivations of industry, or were very positive about their role in sustainability. Trust in industry to deliver a sustainable bioenergy sector appeared to be associated with the desire to see a rapidly expanding bioenergy sector. The first quote below (quote 74) represents one of the more positive perspectives on the role of the agricultural industry, while the second quote (quote 75) takes a less optimistic position. The second

quote was taken from a response to a question regarding the feasibility of introducing effective accreditation for biofuel sustainability.

> *74. People who are engaged in agriculture are incredible tenacious and have very good record of achievement and so we will see them moving into more sustainable agricultural systems globally, I'm convinced. (UKERC member)*

> *75. I don't think we're doing it on food supply [regulating it sustainably] and that that's much more immediate to people's concern. The supermarkets tighten up when they feel they need to, but I'm certainly not convinced that the same standards are used everywhere; they will claim that they are, but one keeps seeing exceptions to it. The same with textiles, if child labour is being used, if they can get away with it they will do I think. Clearly we know that biomass production, if we think of logging and such like, huge huge problems there, and big corporations with lots of vested interests in not being accredited. I don't know, I would have thought effective accreditation is really a long way off. I theory we've had voluntary accreditation for tropical hardwoods for garden furniture and such like, it's not something I've really looked at but I suspect that you'd have to go through the typical garden centre looking pretty hard to find something that came from a verifiably sustainable source. What chances are there for something that is just going to be burnt that people can't even see (RELU-Biomass member N)*

6.4 Green radicals, economic rationalists and sustainable development

Despite the varied views on bioenergy, there were underlying similarities to even some of the seemingly conflicting opinions over the use of bioenergy. While the discourse types as set out by Dryzek (1997) are seemingly not directly related to or limited to the various claims about land availability and the nature of transport in relation to the rest of the energy sector (and therefore not directly and simply related to support for different bioenergy technologies etc.), they do provide a useful framework for discussing these underlying discourses

around bioenergy. A couple of these, namely ‘green radical’ and ‘economic rationalist’ are identifiable as particularly contrasting discourses. However, whilst it was not possible to satisfactorily type individuals by discourse type (on the most part individuals each had their own highly considered context specific positions on bioenergy), the overwhelming majority of the discourse could be considered to be what Dryzek would type ‘administrative rationalist’ or weak ‘sustainable development’ This section will thus briefly explore the existence of these broad discourse types.

6.4.1 Green radical

Though there was little in the way of discourse that was suggestive of a radical green agenda within the projects, there were a few individuals that utilised this type of discourse. While there was much discussion by interviewees around the benefits of bioenergy in terms of decentralising the energy system to some extent, some of this discourse appeared underpinned by a strong sense of responsibility toward self-sufficiency in the sense of a premeditated withdrawal from a globalising economy (quotes 76 and 77).

> *76. I think the whole concept of being able to produce the energy you need on a local scale, so you are as self sufficient as possible is just ideal. (RELU-Biomass member V)*

> *77. I think decentralisation would be key to try and remove us from this idea of a global system where you can say “well lets think of planting up Jatropha on this marginal land in India”, well fine do it, but that’s for the Indians not for us. We shouldn’t be saying that’s great if you do that, we should be saying “what can we do here for ourselves?” We should then be saying we need to cut back on our consumption. (UKERC member W)*

A defining characteristic of green radical discourse is a questioning of the fundamental sustainability of liberal capitalism. While the majority of the discussions around the sustainability of bioenergy concerned regulation and

new technology, a small number of individuals made explicit reference to the need for more radical change. While quote 78 below represents the only individual to directly critique economic growth, a number of individuals made comments suggestive of this.

> *78. all societies operate on the basis of having you know, three to five percent economic growth year after year after year and the problem is that economic growth in the current economic model is driven by activity. So if there is an activity the GDP goes up, if there's not an activity it doesn't go up. Activities tend to consume resources and create waste. So until we start to get to quite different economic models it's very hard to see how we can have sustainable development (TSEC-BIOSYS member U)*

Linking this discourse to any particular position on bioenergy is difficult. While one might expect these individuals to be associated with a rejection of biofuels because of its current association with globalised agricultural trade, the relationship is not so simple. The individual from which quote 78 was taken was relatively optimistic about biofuels and also referenced in the section below, seemingly ascribing to a particularly economic rationalistic perspective.

6.4.2 Economic rationalist

In contrast to more radical discourse above, there were also a number of respondents who drew on a very free-market orientated discourse, more akin to the dominant energy discourse. Under an economic rationalist discourse, it is an international trade in bioresources, and a healthy global market that is most desirable. The three quotes below were all form individuals with very strong views on the desirability of biofuels (quotes 79-81).

> *79. Importing biomass liquid or solid will be very important because competition is healthy. In Europe there is not sufficient biomass (TSEC-BIOSYS member X)*

80. But eventually when we get these criteria then we could have something like an A grade and a B grade and a C grade and again that's why education is important because people, you can imagine one day if you want to fill up at the pump, you can actually choose to get something a bit cheaper but less sustainable or something, might pay a bit more and certified to be more sustainable. Or it might be the other way round cos the more sustainable one gets more of a subsidy. (TSEC-BIOSYS member U)

81. I prefer a more diffuse sort of genuine public feeling for it, where people do go out and spend there own money on doing things that deliver a benefit; of course that means good quality, objective information, that's perhaps somewhere where policy could work quite well; make things overt, make things absolutely crystal clear to purchasers what it is they are doing when they buy a particular product. So I'm a bit more Adam Smith about it, stuff doesn't happen unless there's a market for it. (TSEC-BIOSYS member L)

6.4.3 The hegemony of pragmatism and administration

One reason why it was difficult to ascribe individuals to strict discourse types was because most discussions of bioenergy were very measured and caveated. However, while there were some very strong views about the desirability of certain technologies and practices, most interviewees drew on what could be considered a much more 'pragmatic', management type discourse. This is not to say that the associated narratives were necessarily the result of more reasonable or considered positions than those with seemingly stronger views. Rather, that these narratives were often grounded in more of an explicitly apolitical, management type discourse. In this sense they could be seen as drawing heavily on Dryzek's (1997) discourses of administrative rationalism and a rather weak version of sustainable development.

Both of these discourses are optimistic, management type discourses. While the administrative discourse assumes the natural world to be manageable, and that big government advised by big science is the way to do it, the sustainable development discourse is more imaginative and nuanced, drawing on concepts

such as cooperation and a global perspective. Thus, while many interviewees recognised the problems with current biofuels production, most where nevertheless optimistic in the ability of regulation, or of second or third generation technology to manage these issues. However, in the context of the interviews, the discourse was much more centred on the ability of science to come up with the right answers, than on the possibilities of implementation under the current political economy. Unlike the energy policy discourse, much of the discourse concerned more prescriptive accounts for the desired development the sector. This administrative style of discourse is technologically optimistic, and represented well in the quote below (quote 82)

> *82. In terms of LCA and biofuel accreditation we need some way of assessing reference land use or displacement land use, which the only way I can see of doing it is having a world model with all land use in it, it might almost have to be theoretical, where you say well this how much land we have, these are all the things we need from the land and that would have to include things like increases in population growth, what food people are going to want, how much land is available, how type of land is available. That would let you start to look at this issue that even if you're not growing biofuels on land which is have high carbon stocks or which is a biodiversity hotspot, what is the displacement affect. But that shouldn't just be looking at biofuels, that needs to be done for our land use in general. (TSEC-BIOSYS member T)*

Much of the discourse centred on the technical potential of bioenergy, and much more emphasis was put on this than on the likely transition of technical potential into political reality. While there were different opinions regarding the trustworthiness of industry and the efficacy of policy to bring about a transition to a more sustainable development, much of the discourse was focused on getting the science right rather than being concerned with the impact of the science on policy or commercial deployment. This view seemed to be associated with a view of science driving the policy in regard to sustainability. Though some of the less positive and optimistic discourse was associated with cynicism over the aims political drivers of biofuels policy in the UK and EU, this administrative type discourse was generally associated with a belief that policy had been primarily driven by concern over climate change. Where there was a

certain uncertainty over the political feasibility of regulating bioenergy at an international level, a number of individuals instead proposed that regulation 'would have to work' (quotes 83-85).

> *83. It's going to be difficult [implementing a global sustainability standard for biofuel production]. It's going to have to work at the end of the day because we need something. There has to be an accreditation scheme, because if there's not there's nothing to stop the use of. ..Rather than an accreditation scheme of a carbon balance or a land use, would be to push for second generations a lot more. (TSEC-BIOSYS member T)*

> *84. That's a difficult question to answer. Somehow to say it's not achievable seems terribly negative. (SUPERGEN-Bioenergy member M)*

> *85. It's extremely important. It's extremely complex area because it's never clear where you draw the boundaries. I think it's also very difficult to assess certain impacts for example on….if you take a crop growing in an area, it may look from the one hand that you're exploiting the local labour force; on the other hand it may be that before that crop was there, they had no income. So I think it can be very difficult to make judgements on some of the effects or impacts of this industry taking off in different parts of the world, but some how we need to try and do it. (RELU-Biomass member S)*

A common assumption underpinning a lot of the individual narratives on bioenergy was the inevitability of technological progress and an associated lack of political efficacy. This general attitude toward biofuel accreditation was summarised by one member of the TSEC-BIOSYS project (quote 86).

> *86. But unless you start [with trying to design and implement a system of sustainability standards for bioenergy] you'll never finish with that sort of activity. (TSEC-BIOSYS member U)*

Conclusion

This chapter has explored very broadly the way that the projects of interest have engaged with the debate about the sustainability of bioenergy, both in the questions that they ask and in the way they communicate with non-academics. At this time, while these projects represent the vast majority of Research-Council funded science on the subject, it appears that they fail to engage with what could be considered some of the more pressing framings of bioenergy sustainability. It is clear that in taking a national focus and conceptualising bioenergy sustainability as primarily a matter of least cost decarbonisation, and sustainability as primarily a national issue, the projects do not directly challenge the dominant discourse on bioenergy. Rather, framed in the language of sustainable development, if anything they appear to broadly reproduce the UK Governments position. While RELU-Biomass differs from the other three initiatives, arguably taking a broader project- wider approach to sustainability, in focusing explicitly on the UK, it also sidesteps many of the contentious issues surrounding bioenergy. While the primary focus of research-council science, opens up a number of questions regarding the political role of publically funded research, the reproduction of many of the storylines used by the pro-biofuel coalition (particularly on the UKERC website) is a more obviously political act. This material actively depoliticises the issues surrounding bioenergy, both in its specific claims and its construction of sustainability as primarily an issue of technocratic management.

As indicated in this chapter however, the online material does not capture the variety of positions held on bioenergy within the projects. While there were many strongly held views over bioenergy, many of the views were very positive over the potential for bioenergy. However, while the potential of bioenergy is bought into, the discourse is more managerial, and much of it would be classified as what Drysek (1997) would consider administrative rationalism or weak sustainable development. While this chapter, has painted the projects with a broad brush, the next chapter explores some aspects of theses projects in more detail. It also sets out to ask why it is that the projects have engaged with the politics of bioenergy in the way they have.

Chapter 7 A politicisation of science?

While the last chapter set out a very broad analysis of the projects in the context of the debate over bioenergy sustainability, this chapter explores some of the issues raised in more depth, and also provides some potential explanations as to the way the projects have engaged with the issue of bioenergy sustainability. In particular this chapter looks for explanations in the structures and practices underpinning the dominant ecologically modernistic discourse. However, it also focuses on the interaction of this discourse with powerful narratives within science itself. Apart from SUPERGEN-Bioenergy 1, all of the projects were commissioned just at a time when many of the concerns about biofuels, particularly soya from South America and palm oil from SE Asia, were beginning to be raised. They have also operated through the very public debate over biofuels. All of the projects, apart from arguably the RELU project (due to its more defined remit and budget) also had a certain amount of flexibility built into them. Thus while funded with set objectives, these were in most instances broad. Much of the actual focus of the projects was worked out during the running of the project (e.g. quote 87).

> *87. when the proposal is written, it's never that precise because it needs to leave a bit of freedom for people to explore what would be interesting for the project. Also you don't want to promise the moon if in the end you cannot deliver what you said you would; so I think it still stays vague. . (SUPERGEN-Bioenergy member C)*

7.1 The hegemony of relevance

Science plays an important role in ecological modernisation. As well as representing the driving force of innovation, it also provides an increasingly important evidence base from which environmental regulation can legitimately be drawn. Weak versions of ecological modernisation, as arguably seen in the

UK, are thus increasingly characterised by an increasing technocratic environmental decision making (Liftin, 1994; Pimbert and Wakeford, 2001; Jasanof, 2004). As such, particularly in the last 10 years, there has been an increasing emphasis in science policy on policy relevance. In the 1990s, science policy started to place more emphasis on the role of publicly funded research in addressing social problems, particularly economic competitiveness (David 1997), and in 1993 it was made explicit that the new aim of science policy was to achieve 'better communication, interaction and mutual understanding between the scientific community, industry and Government Departments (DES, 1993). As such, Research Council missions were revised, and mechanisms, such as research 'themes' were introduced in order to enhancing the relevance of their research (Scott, 2004). Subsequent White Papers on science, innovation and competitiveness have also emphasised the need for science to play a greater role in wealth creation and addressing society's wider needs (DTI, 1998; DTI, 2000; DTI *et al.*, 2002; HM Treasury *et al.,* 2004).

In association with the 2004 Comprehensive Spending Review, in late 2004 the Treasury published its latest ten-year framework for science and innovation (HM Treasury *et al.*, 2004). The framework sets out the Government's ambition for UK science and innovation up until 2014. As with previous white papers, science is set within a context of innovation and the primary aim of the strategy is in promoting greater responsiveness of publicly funded research to the needs of the economy through commercialisation and knowledge transfer (HM Treasury *et al.*, 2004). The drive for relevance in publically funded science has led to greater emphasis on strategic research, greater competition and much more of an institutionally embedded concern with ownership of knowledge. Just as scientific policy making can be viewed as a form of practice structuring bioenergy politics and energy policy outcomes, so it can also be seen to influence research-council funded science. This section will now explore the way that these practices have fundamentally constrained research into the sustainability of bioenergy.

7.1.1 Structuring science

The most obvious impact of the increasing influence of scientific policy making and its focus on relevance is the funding of research through strategically managed programmes of research. This also goes someway to explaining the broader conceptualisation of sustainability within the RELU funded project. While the projects considered in this thesis represent the vast majority of the research into the sustainability of bioenergy, apart from the RELU-Biomass project, all the initiatives are funded through EPSRC's 'Energy Programme'. Whilst this may seem unsurprising given the nature of the research, the bounded remit of this programme has nevertheless arguably influenced the breadth of the research. The energy programme draws its strategic aims directly from the energy policy. Thus, research funded through the energy programme is explicitly designed "to help the UK meet the objectives and targets set out in the 2003 Energy White Paper". As has been argued already, despite the framing of energy policy in a broad context of sustainability the aims of the white paper are much narrower. Within energy policy, a consideration of the wider sustainability issues associated with bioenergy is not of primary importance and may even be in conflict with a desire to diversify the UK's sources of energy. Though this point may seem banal, it is made both to stress the strategic nature of bioenergy research of this kind, and more importantly, to make the point that while seemingly unquestioning support for government policy may appear to represent a lack of reflexivity on the part of the research community, it may also be conceptualised as symptomatic of the current focus on relevance in strategic research more generally. It is also possible that the very strategic nature of the research strongly influenced the content of the project websites (although see section 7.2 below).

The role of the research councils in structuring the focus of research in to bioenergy was discussed at length by one of the interviewees. While there would appear to be a lack of research effort into the impacts of trade on socio-environmental systems beyond the UK's boundaries, a senior researcher working on the environmental impacts of second generation crops in the UK

also voiced concern over prioritisation of research effort in the UK (quote 88). The researcher repeatedly voiced concern over the focus of the ecology programme, drawing attention to a number of very similar studies that had been carried out previously. The critique was extended to similar work being conducted on other projects. The same sentiments are also evident in quote 89.

.

> *88. I sometimes wonder, why just keep on studying this, why not just do it. In my more kind of cynical moments I think 'why do we study these socio-economic implications of cropping. Why do we keep on studying it really, you know cos we keep on doing it, …..Doing this R and D work is an excuse for not doing it properly by the government. And it's like "well we're looking at that" so actually they're not doing anything really. It's almost like the modern way isn't it, it's just like a political tool to get yourself out of a hole. "we are doing something" and that's why a lot of work is being repeated, and it is, it really is bit of a kind of; you know we're one of the least corrupt societies and you can't complain there's always a bit of nonsense going on isn't there. But I think there's quite a lot wasted public money going on…… its just completely over the top [the methodology] when you've got something like SRC, which is full of insects and weeds. You just need to go in and make a few notes, you don't need to collect really detailed data to tell you that it's full of insects and weeds compared to wheat, but that's what we've done….It's not the right bit of work to be doing (Ecologist)*

> *89. There's something about the [funding] process that allows these big pointless projects to get funded all the time now. (RELU-Biomass member Q)*

7.1.2 Relevance and competition between the projects

While the focus on relevance has had a large influence on agenda setting practices within the research councils, it has also shaped the nature of the reward system in science. While this has been demonstrated to be a barrier to interdisciplinary and interactive research by itself (Scott, 2004), it is also clear that, in the case of bioenergy research, competitive pressures have had an impact in terms of limiting the interaction between the different initiatives. Given

the length of the projects, all projects temporally overlap. While the author experienced some difficulty gaining access to information about research on the projects, it is evident that this was also the case for a number of researchers working on the projects. The difficulty in gaining access to information on other projects as detailed by the researcher below (quote 90) was expressed by a number of individuals.

> *90. What UKERC does is provide the opportunity for it by convening events, but all the other drivers are against integration. So if there's no financial; it all comes down to money and careers and that's all related to publications; if there's no incentive in those aspects to collaborate, then it relies on goodwill, and goodwill is severely lacking in a lot of academia. It's really competitive, it's really hard to get grants, so people are, can be very closed about it, which is a real pain.*
>
> **What do you see the project achieving?**
>
> *If I'm honest, very very little and it is just terrible and I think that is because we are not working together as we just described. What is the point of us probably replicating great chunks of TSEC, I don't know what TSEC are doing, I wouldn't know if I'd replicated them. (SUPERGEN-Bioenergy member)*

A surprising aspect to come out of the interviews was the general lack of knowledge among project members about what the other projects were doing, even between those working in similar areas. One of the roles of UKERC was to co-ordinate this kind of research. However, there were mixed feelings as to the success of UKERC in achieving this objective. While UKERC has undoubtedly helped, as explicated in the quote above, there are a number of other drivers against cooperation. This perceived lack of coordination between the projects was apparent despite a number of individuals being involved in more than one of the projects. This lack of connection between the projects was most evident in dialogue with one project members. Despite running the environmental assessment theme in their respected project, this individual used the fact that RELU-Biomass was engaged in looking at the wider issues around bioenergy sustainability, to justify the narrower focus of their work. (quote 91).

91. But there is a need to look at that whole global land picture and I'm presuming that your RELU people are hopefully looking at these sort of issues (senior project member working on environmental assessment theme)

7.1.3 Timescales

Another issue to emerge from the interviews concerned the different time-scales of science and politics. While the projects represent some of the first, as well as the majority of the research into the sustainability of bioenergy in the UK, they are all large and relatively long endeavours. The debate over the sustainability of bioenergy has moved quickly, and in many ways a lot quicker than the projects can adapt. This mismatch between academic and policy timescales was bought up by several interviewees from different projects (quotes 92 and 93).

92. it's to do with the generic way in which academic research is funded, so we're very slow, we have these long time scales. It takes a year to get something, before you, you write it. It'll take a year before you start it. It gets out of date. (SUPERGEN-Bioenergy member A)

93. I think we need to find ways of harnessing it [science] for more short term and policy focused questions. TSEC's been useful, but it's taking 3 years to answer questions that could probably have been answered in 6 months to a year, if people had really put the resource together and done it and had the right motivation to do it. .. ..The thing sort of meanders on, and we're coming toward the end and it's 'oh god, does this all fit together' and the answer is 'probably not', so there'll be a big rush at the end and frankly it could have been done in 1 year or 2 and it would have been more timely. (TSEC-BIOSYS member F)

While some saw the length of the projects (including the commissioning process) as problematic in terms of relevance, many interviewees also noted

that this time was necessary in such interdisciplinary projects to build relationships and learn the appropriate language of other disciplines. There thus appears to be a trade off between these aspects of policy relevance and 'learning to do' interdisciplinary research. While reflexivity on the projects, in terms of reacting to and predicting policy relevance, may be inadvertently affected by their relatively long time spans, one project member also suggested that this might actually actively stop consideration of certain issues. In quote 94, the researcher suggests that the controversy over biofuels may actually have limited research into biofuels on the grounds of perceived relevance:

> *94. It [SUPERGEN-Bioenergy 2] doesn't have a position on biofuels. **** didn't want to focus on biofuels too much because it was too controversial and policy makers might decide it was a bad idea and walk away from it. That we didn't want to produce research after 4 years that was no longer relevant which you can understand. But over last two years the government hasn't walked away from biofuels and it's still on the agenda, and I understand her concern but it crucial to look at biofuels. (SUPERGEN-Bioenergy member C)*

7.1.4 Structured interests

In conceptualising the public as in need of education about bioenergy it appears that, as researchers involved with bioenergy, many individuals assumed a certain amount of responsibility in promoting bioenergy. There is some evidence to suggest that this sense of responsibility may be associated with a personal or professional investment in bioenergy. Quote 95, from one member of the RELU-Biomass project seems to suggest that this might be the case.

> *95. I can think of some meetings where people might start to get a bit defensive about what the implications of some results might be for the future of biomass planting if we're not very careful about the way we report them. So I think people begin to feel ownership, whether they admit it or not for biomass because they are working on it and also because they are dealing with stakeholders who have business interests in it. (RELU-Biomass member Z)*

While this quote represents the only direct evidence for this claim about alleged 'ownership' of bioenergy, some of the discussions the author had in the interviews was suggestive of this. In the first quote below the interviewee stresses the point about their impartiality, 'even though they are a bioenergy person'. The desire to be the person to discover new bioenergy technology also suggests their personal commitment to bioenergy (quote 96). Quote 97 makes a point that arose several times in the interviews; that is the need to manage peoples' perspectives of bioenergy. In this quote the interviewee is concerned that the bad press that biofuels is getting will spill over into concern about bioenergy in general.

> *96. we're trying to assess the sustainability of various technologies and weighing them up. If it came out that bioenergy was not attractive compared to wind power for sustainability for carbon-foot-print, it would be my job to say that, even though I'm a bioenergy person, hey look guys these bioenergy systems, they're just not effective, they're not going to be sustainable, they're using too much carbon, through nitrogen fertilizers. So, …I'm gathering the evidence base and trying to be fairly impartial, and then of course I'm hoping for new discoveries. I'm going to be the person who discovers the best poplar tree in the world that just falls apart and turns into bioethanol, I'm going to be the person that discovers the microalgae for biodiesel that just runs out of the cell. So, I'm also trying to make new discoveries. (TSEC-BIOSYS member D)*

> *97. There are some serious issues with biofuels, both with the public conception of them is one of them, that there is a real risk that bioenergy development could be stalled if the bad press that biofuels is going to get, if people connect the two, which realistically they are connected because some of the fuel sources are the same, you can theoretically eventually use wood. (TSEC-BIOSYS, member T)*

It would appear that there is some evidence that 'interests' in bioenergy may be discursively constructed. While there are obvious implications of identifying as 'a bioenergy person', it is also possible that interactive practices defined by relevance that identifies stakeholders primarily by economic involvement may

also structure interests. This raises important questions regarding the legitimacy of current practices and their relationship with particular interpretations of relevance. Despite a broad engagement within RELU-Biomass and some work carried out under theme three of TSEC-BIOSYS and theme 6 of SUPERGEN-Bioenergy, 'stakeholders' within UKERC, TSEC-BIOSYS and SUPERGEN-Bioenergy were defined primarily as industry and government interests. For example, UKERC's aspiration to neutrality was jeopardised in January 2008 when it became associated with some pro-nuclear power comments. This led to the loss of the only NGO representative on its advisory board. While UKERC interact with a wide range of 'stakeholders', it is recognised that NGOs are one group with which engagement could be improved (quote 98).

> *98. We should do better with NGOs than we do at the moment (UKERC member, F)*

7.2 Relevance and objectivity

While instances of interdisciplinary, end-user engagement and wider participation in science are becoming ever more common, it is not without a certain amount of resistance. Traditionally science has been built on the ideals of autonomy, objectivity and purity. Ever since the enlightenment and Descartes, the view that science should separate facts and values and pursue objective knowledge, has been central to modern science. This 'positivism', associated with a commitment to an absolute separation of facts and values (and observer and observed) has been hugely important in the development of the natural sciences and social sciences. One of the biggest objections to a more relevant research comes from the traditional discourse of autonomy and objectivity central to the claimed epistemological authority of science. The arguments against a more interactive, or user-directed research highlight the age-old tension between 'relevance' and 'autonomy' in science (Rosenberg 1991).

Despite being framed in the language of sustainable development and having an obvious relevance to policy, there were strong feelings throughout the projects as to the independence and objectivity of the projects. For example, it was stressed on the TSEC-BIOSYS website that the project aimed to "provide authoritative and independent answers on technical, economic, environmental and social issues related to the development of bioenergy in the UK". In the same tone, UKERC has a policy to "inform but not influence". While interviewees had different opinions on bioenergy, the majority were keen to stress the independence of their science from politics. Many described a linear view of policy making, with themselves as providers of an 'evidence base' from which policy could be made. This desire for objectivity was particularly evident in the way the concept of sustainability was conceptualised within the projects.

7.2.1 Sustainability and Ambiguity

As a concept, sustainability was often seen as being of limited scientific use. Although the majority of individuals interviewed were happy to use the term in the ways previously illustrated, there was also a certain unwillingness to engage in further discussion as to its meaning. As such, it was clear that while framed in the language of sustainability and sustainable development, particularly outside of the themes directly concerned with sustainability assessment, the concept was largely used rhetorically. Apart from within RELU-Biomass, within the projects there appeared to have been little to no discussion about the meaning of sustainability and the implications it had for the way that research is conducted. As has already been discussed, much of the time it was used automatically as synonymous with the goals of energy policy. The view that such discussions over sustainability were unnecessary was expressed by one interviewee, responding to a question concerning the use of sustainability as a concept in science (quote 99).

> *99. I really don't find any particular value of doing nuances scientific interpretations of phrases that were generated in a slogan or a bureaucratic kind of way. If you have a TSEC programme, we know vaguely what you mean, but there's no point in dissecting the concept*

because it wont' get you anywhere, I don't think. But that's because I've been around this too long and I've got a bit cynical about the way programmes are developed. (UKERC member, F)

It was also clear that apart from within RELU-Biomass, the language of sustainability and sustainable development was also used rhetorically in the original construction of the projects. This is not to say that the individuals within the projects were apathetic to, or uninterested in, contributing to the social good (the majority of individuals cited this as a major motivation for their research). However, it appears that outside of the goals of energy policy, the concept was not seen as very useful or as particularly relevant to research of this kind. The three quotes below are all from individuals involved in the original setting up of the three projects (quotes 100-102).

100. The reason for putting that in [environmental sustainability] was; when you get that kind of invitation to bid, with all these complicated words and adjectives about whole systems and integrating, to be cynical, all you are doing in putting in a proposal is rearranging these words and putting them in a different order, and the ES theme was intended to signal that we took the TSEC programme concept seriously (UKERC, member F)

101. I don't recall any debate on that. I suspect as grasping researchers, we just chucked the word in where it would help get the grant. That's a little bit over cynical perhaps, but there is an element of that, but we would have used it in a devalued way without thinking about it much. I don't think…when we were getting it going that we had a great debate about what is the meaning of sustainable. I think we've been as bad as everybody else. (TSEC-BIOSYS member I)

102. **What is the function of the language [of sustainability]? Why is it used?**

Sounds good, sexy.

Gets money?

Yah, (SUPERGEN-BIOENERGY member P)

While the terms sustainability and sustainable development were used interchangeably throughout the projects, some individuals made a distinction, stating that they were interested in the sustainability of bioenergy, but were unsure of how this related to sustainable development, or that they were interested in 'surrogates' for sustainability. While sustainability under this distinction seemed more synonymous with 'longevity', it also seemed to include aspects of a Bruntland like sustainable development concept in an *ad hoc* fashion. Two member of the TSEC-BIOSYS project were fairly cynical about the use of the concept within the project (quotes 103 and 104).

> *103. Sustainability is one of these little buzz words that people use without actually having a huge amount of contact with what they are actually trying to define. What they want to do is not upset anybody, is what they mean by sustainability. …….sustainability is a concept, you can measure it if you are a physicist but that's not really what we're looking at, so. (TSEC-BIOSYS member T)*

> *104.* **Does TSEC-BIOSYS have any definition of sustainability?**
>
> *…. No, the answer is no. There's no official definition but I think it's become almost jargon now. People think that everybody knows what we are talking about and what the project is supposed to do. (TSEC-BIOSYS member E)*

While natural scientists, social scientists and engineers all used sustainability as synonymous with either carbon abatement or renewability in discussions of bioenergy, the organisation of the projects around the three 'pillars' of sustainability (economic, social and environmental), in many instances forced a more nuanced consideration of the concept. One way that the complexities of the concept of sustainable development were dealt within the projects was by demarcated sustainability into its 'three pillars'; the most obvious example of this being the 'Environmental Sustainability' theme in UKERC. This splitting up of sustainability effectively allowed individuals to remain within their disciplinary boundaries. This reductionist approach to sustainability was voiced by a number of individuals, and is demonstrated in the quotes below (quotes 105 and 106).

105. Well, there's environmental sustainability, then there's social sustainability and then there's socio-economic sustainability, so that's a very big area, it's almost as big as science itself in a way. (UKERC member)

106. ***On the TSEC project is there any working definition of sustainability?..*** *I can't remember If there is any official definition….because it's multidisciplinary we each have our own sustainability criteria. There's an economic sustainability as well…..the social scientists will probably say, well you've got to be sustainable as in you mustn't dispossesses people. They must be allowed to sustain their standard of living, would be their equivalent of sustainability, whilst mine would be more of the genetic biodiversity or the land management side…so you could bring all of those together and have an overall sort of list, these are our sustainability , and each group would be almost responsible for giving each one of those…….that's the thing about sustainability, depending on what you are looking at it means different things, but as a group we should have all of them covered really….(TSEC-BIOSYS member T)*

Whilst within the projects the language of 'sustainability' and was used in various ways, outside of a recognised need for a multidisciplinary approach, sustainability was almost exclusively conceived of as a state or characteristic of a technology rather than a concept that impacted upon the way science was to be practiced. To this extent, it was only within the RELU initiative that any project wide discussions over sustainability took place. Being an 'unscientific' term, discussions over sustainability were seen by many as unnecessary (quote 107).

107. I think among people that do research into bioenergy, I think there is an understood definition of what sustainability means, which is about…a very low level of life cycle green-house-gas; well the first thing that would be understood by everybody would be that you need a lifecycle type of definition, so that you are tracking the system all the way through, you would be looking for green-house-gas emissions, you would be looking for very low non-renewable impacts into the system, you'd be looking for something that was socially acceptable and that didn't cause any kind of environmental pollution

and which essentially you can go round and round in cycles without disrupting lets say the biosphere generally.. so I guess it's not so explicitly articulated because people have reasonably common understanding of what that means. (TSEC-BIOSYS member U)

While the vast majority of all interviewees admitted to be motivated by a personal commitment to contribute to the common good, it was clear that a perceived lack of engagement with wider sustainability issues within the project has led some members of the SUPERGEN-Bioenergy consortium to question the motives of other researchers on the project (quotes 108-110).

108. My experience probably is that sustainability isn't a key priority [for most researchers]. It's about the research they do rather than; It's a love for the research they do and it doesn't matter where that funding comes from and it doesn't matter if it's environmentally or sustainability focused as long as they get the money. (SUPERGEN-Bioenergy member C)

109. There's no question over whether this [bioenergy] is a good thing or not (SUPERGEN-Bioenergy member C)

110. Largely its [sustainability] been used rhetorically. In case for support it's often been used rhetorically, in websites it's used rhetorically. It's really up to the individual researcher's definitions and interests. (SUPERGEN-Bioenergy member A)

It is obvious that as well as being used loosely (because of the perceived lack of relevance it holds for science practice), in many instances sustaianbility is used in strategically ambiguous ways (Eisenberg, 1984). It can thus be seen to be serving an 'enabling' function, providing both intertextual coherence (Fairclough and Wodak, 1997) between the project themes and the projects and research councils, and facilitating an appeal to multiple possibly incommensurable ideological perspectives (Leitch and Davenport, 2007). The use of sustainability terminology can thus be seen to create coherence between the aims of the particular research projects and the aims of other, possibly conflicting

discourses around bioenergy and the environmental more generally. While, the three energy programme projects were all engaged in strategic sustainability research, it is clear that for the mainstay, any consideration of sustainability beyond the goals of energy policy was deemed unnecessary and unscientific. Having said this, there were elements of all of the projects that took a more reflexive approach to sustainability. However, as will be explored in the next section, this was not without a certain amount of resistance within the projects at large.

7.3 Relevance and legitimacy

The widespread commitment to an absolute separation of science and society and a linear view of policy making, as an explanation for an apparent lack of reflexivity on the energy programme projects is further reinforced by views on the role of public engagement within the projects. These views were also related to the perceived roles that the 'social' research themes played in the SUPERGEN and TSEC initiatives. Whilst the role of research-council funded science in addressing issues of sustainability is increasingly being recognised, the centrality of economic objectives is still evident in the emphasis put on industry collaboration and knowledge transfer (HM Treasury *et al.,* 2004). This trend is reflected at the EU level, and has led to the observation that "Policy for PSR (*public sector research*) in Europe is privileging industry and the promotion of innovation, and appears to be assigning a lower priority to its responsibility to act as a 'watchdog' in matters concerning research which may affect public safety, the environment, sustainability and so on" (Senker, *et al*. 1999). As discussed in chapter 2, primarily in response to research increasingly being conducted within partnerships comprising the public and private sectors, and largely driven by a perceived 'legitimacy crisis' in modern science (Backstrand, 2004), there have been calls for research decision-making and agenda setting to become more transparent and democratically accountable (i.e. Lubchenco, 1998; Gibbons, 1999; House of Lords Science and Technology Select Committee, 2000; Gallopin *et al.*, 2001; Kates *et al.*, 2002; ICSU, 2002; ICSU, 2005).

Just as interdisciplinarity and interactivity are seen as useful in delivering relevance, these practices also underpin a move towards a greater democratic legitimacy in science. While interdisciplinarity and interactivity are often seen as separate endeavours, they can also be viewed as concerned with similar objectives. Just as interdisciplinarity can be viewed as a way of broadening the perspective taken on a problem, and therefore avoiding partial (disciplinary) framing of a problem, interaction with non-academics (often mediated through social science disciplines) can be viewed as an attempt to extend this recognition of 'other expertise' even further. Thus Strathern, (2004; cited in Lowe and Phillipson, 2006) introduces a radically inclusive notion of interdisciplinarity by suggesting that that 'reaching beyond disciplines merges with reaching beyond academia'.

Both interdisciplinarity and interactivity can be seen as broad categories of practice. In a drive to make research more relevant, demand for interdisciplinary research has mounted, becoming not only an explicit objective of research funding, but also a key means of generating science-policy (Strathern, 2004; cited in Lowe and Phillipson, 2006). Historically, the drive for a more relevant, interdisciplinary science has been fuelled by the recognition of its role as a driver of economic prosperity (HM Treasury *et al.*, 2004), and an increasing demand for usable research in environmental policy and regulation (McNie, 2007). Thus, interdisciplinary research has traditionally been seen as a mechanism for providing greater salience to both the demands of industrial innovation and policy making. However in broadening out, to include disciplines explicitly concerned with issues of accountability and with possibly different epistemological commitments, it also has the potential to help address issues of democratic legitimacy in science.

It is principally the drive for relevance in science that has resulted in concerns over legitimacy. Interdisciplinarity and interactivity can be seen as practices that are designed to 'include' more interests in the creation and interpretation of new knowledge. However, it is the inclusion of some interests (primarily business and industry) to the exclusion of others that has driven concerns over

legitimacy. In many respects, relevance and legitimacy can be seen to be in tension with one another (Kates *et al.*, 2001). Making science relevant to one group of interests is most likely to come at the expense of deeming competing interests 'irrelevant'. Likewise, as discussed in chapter 2, practices such as public engagement (involving the representation of a broader set of interests in the mechanics of knowledge generation) can be underpinned by differing rationales; rationales which are often tension.

7.3.1 Interdisciplinarity and interactivity on the projects

All of the projects involved public engagement activities designed to 'reach beyond' a one-way communication between project and the public. As has been already discussed, much of this primarily involved interacting with government and industry interests. However, RELU-Biomass, TSEC-BIOSYS and SUPERGEN-Bioenergy also contained aspects that potentially sought to involve wider 'interests' in the process of knowledge creation. Being built around a 'stakeholder' informed sustainability appraisal, the most obvious and far-reaching of these process was found in RELU-Biomass. The RELU programme itself, also differs form the other funding programmes in that wider stakeholder engagement also contributed to setting the broader funding agenda (for a review see Lowe and Phillipson, 2006).

Within SUPERGEN-Bioenergy and TSEC-BIOSYS, dedicated public engagement was carried out primarily within themes 6 and 3 respectively. While the entire projects were set in the context of sustainability, it was interesting that it was these themes that most people referred to as the 'sustainability theme' of the project. Within SUPERGEN-Bioenergy, outside of contact with industrial partners, it was this theme that engaged more widely in the context of its research. While TSEC-BIOSYS did not have non-academic partners contributing to the direction of the project, it did run a number of formal stakeholder engagement exercises. The broadest of these involved a number of workshops and focus groups run as part of theme 3's sustainability appraisal.

However, a number of other engagement exercises were also run as part of theme 1. While those conducted under theme 1 were focused primarily upon eliciting perceptions of, and barriers to bioenergy uptake, theme 3 engaged a broader set of stakeholders around more general issues with bioenergy development. The aim of the theme was, through public engagement, to develop a set of narratives about bioenergy using utopic and distopic visions of its development. While the engagement activities carried out with TSEC-BIOSYS and SUPERGEN-Bioenergy did not involve upstream agenda setting, they could be considered as having potentially substantive or normative aims underpinning their efforts at public engagement. What was obvious in both SUPERGEN-Bioenergy and TSEC-BIOSYS were the tensions that lay between these themes and the rest of the project.

7.3.2 Project tensions

Due to its explicit commitment to forwarding a bioenergy industry, the most evident tensions were apparent in the SUPERGEN project. As already discussed in chapter 6, whilst SUPERGEN-Bioenergy is explicitly concerned with the forwarding of a bioenergy industry (quote 111), theme 6 of the project is also explicitly engaged in assessing and ensuring the sustainability of bioenergy from a wider perspective (quote 112).

> *111. To build closer and more effective bridges between the emerging bioenergy industrial sector and the wide ranging academic research so that rapid implementation and commercial exploitation can take place (SUPERGEN-Biomass website)*

> *112. We will also be looking at the impacts of biomass on the environment and the rural economy, to ensure energy production is sustainable (SUPERGEN Brochure)*

While these objectives are not necessarily directly opposed to one another, they represent very different potential approaches to the study of bioenergy, and

associated conceptualisations of sustainability. With theme 6 being involved with engaging (publics) beyond the bioenergy industry in a more substantive way, these differences have led to tensions within the project predicated on differing presumptions about the function of the project (quote 113).

> *113. There's different types of tensions, so you've got normative tensions, with ideas of what the purpose of the consortium is. (SUPERGEN-Bioenergy member A)*

As will be explored further in the next section, one of the roles of theme 6 was to draw on and feed into the other project themes. While in interview most individuals were very positive about the interdisciplinary success of the consortium as a whole, it was also evident that the systems theme's attempts to engage individuals from other themes encountered a certain amount of resistance (quote 114).

> *114. in terms of tension, it is difficult to get, even within theme six, the engineers to sit and talk to the social scientists (SUPERGEN-Bioenergy member B)*

Similar tensions were evident in the TSEC-BIOSYS project. While theme 3 of the project represented some very original work in the study of bioenergy, its rationale was very different to the research in the rest of the project and it was obvious that a certain number of people were quite uncomfortable with this (quotes 115 and 116).

> *115. As always it's the social [aspects of sustainability] that people have difficulty with (TSEC-BIOSYS member J)*

> *116. The eventual project was a forced marriage of at least two different proposals…And I think there are some structural weaknesses that result from that… I think **** and **** their hearts are entirely in the right place and they're trying to do the right thing and produce a good assessment of the potential and so on, but I tend to think the stuff on sustainability criteria that is being done down in ***** is just going off and doing his own thing really. To me it doesn't*

fit well with the other stuff and I frankly don't find it all that useful either, but that's just me…..I feel that it's not very results orientated. (TSEC-BIOSYS member H)

Whilst the tensions within the two projects between the 'social' themes and the wider project may have manifest as differing opinions as to the function of the projects, it was clear that they also represented deeper epistemological tensions. For example, within TSEC-BIOSYS at least, it was clear that the tensions within the project were at least partly due to differing assumptions as to the value of qualitative research (and the epistemological commitments that underpin this type of research). This was made most explicit when the author of this thesis was refused interview by one project member, due to the qualitative nature of the research (quote 117). While the assumed lack of engagement the author would receive from other project member did not materialise, the issue of qualitative research was also raised by the interviewee quoted below (quote 118). The individual referred to in the quote is different to the individual in the first quote.

117. As I mentioned in our short conversation, I miss an "objective" scale for our interview responses and I am surprized that the evaluation will all be qualitative, narrative only. ….. I would emphasize the need for developing a quantitative questionnaire…….I'd be surprized if my colleagues in the TSEC-Biosys and RELU-Biomass disagreed on these issues. After these thoughts, which you could consider with your supervisor I rather not meet for an interview although I am very enthusiastic about bioenergy science and the sustainability issue. (e-mail received from TSEC-BIOSYS and RELU-Biomass member)

*118. I would say no, there isn't any <u>direct</u> opposition [to qualitative research], there's a complete unwillingness to take it seriously on **** part, but that's something else. (TSEC-BIOSYS member J)*

7.3.3 The public as consumers of science

The positivistic nature of much of the discourse over the role of science in sustainability was also reflected in the view of public engagement on the projects. This positivism can also help explain some of the tensions between the 'social theme' and the wider project within TSEC-BIOSYS and SUPERGEN-Bioenergy. While there were many differing opinions on the objectives for interacting with the public and the capability of the public to engage with issues around the sustainability of bioenergy, there were also some common themes. While some of those individuals involved with public engagement exercises saw the interaction as a two way process and necessary for substantive or normative reasons, most interviewees considered the engagement in instrumental terms (it being necessary to engage a naïve public in order to educate them about the potential benefits of bioenergy). For example, two members of the SUPERGEN consortium suggested that the primary function of the public engagement exercises run on this project was to manage the social implications of an expanding bioenergy sector. Outside of those themes specifically concerned with public engagement (and also to some extent within them), interaction with a 'general public' was thus viewed by many as an exercise in education. This is described by a researcher from the TSEC-BIOSYS project, responding to a question over the need to engage the public about more fundamental questions on the desirability of bioenergy (119), and was even evident within the RELU project, as suggested in quote 120 below.

> *119. I'm not convinced that they [the public] should [be engaged over more fundamental issues concerning the desirability of bioenergy] to be honest, because….its just too difficult to explain the question, let alone get an answer. (TSEC-BIOSYS member H)*

> *120. but I can't see that we can progress now into the future meeting all the resource requirements we have without the development of bioenergy and biofuels from crops. …I think they're part of a portfolio of solutions. I can't see we can do without them, so the question for me isn't whether or not we should have these crops and technology, it's how to integrate it in a way that reprieves the pressure on land use for food for example and also…with as many positive outcomes*

and with as few negative outcomes as possible (RELU-Biomass member S)

The perception that in general the public have little capability to engage in a debate about the sustainability of bioenergy was also associated with a general feeling that the public needed educating about the benefits of bioenergy, and that this was the answer to the general ambivalence and opposition to bioenergy within society. Many project members also saw this 'information deficit' as compounded by the dissemination of mis-information about bioenergy in the media. These themes are evident in the two quotes below (quotes 121 and 122).

121. There are some serious issues with biofuels, both with, the public conception of them is one of them, that there is a real risk that bioenergy development could be stalled if the bad press that biofuels is going to get, if people connect the two, which realistically they are connected because some of the fuel sources are the same, you can theoretically eventually use wood. (TSEC-BIOSYS member T)

122. And my personal idea was to have the 'bio-bus'. So, the biobus ran on biofuel, and it was taken round to schools and events where you'd engage with the younger generation, because my feeling is that in Sweden, there is a very active sort of educational programme, in primary and secondary school and those are the guy's we really need to capture. ….. How you interact with NIMBYISM within the adult population I think is really hard. So I can talk until I'm blue in the face about the sustainability of biofuels, but if someone has read the latest edition of the daily mail, that's not going to be very convincing necessarily (TSEC-BIOSYS member D).

An example of this attitude toward public engagement is reflected in the publication of the UKERC's energy research atlas for bioenergy. This document contains the output from a research mapping exercise and the formulation of research priorities for bioenergy. Only one, out of ten "short term research challenges for bioenergy" concerns public engagement, and this concerns the

explicit managing of public values in relation to genetically modified technologies:

> *123. Improve public perception and use of GM technologies for bioenergy. (UKERC Energy research atlas: Bioenergy. Short term research challenges)*

This instrumentality was further suggested in responses to hypothetical questions over the desirability of upstream engagement of the public in setting agendas in bioenergy research. While there were some positive responses to this, the vast majority of respondents saw it as both undesirable and dangerous. This is evident in quote 124 below, taken from an individual involved in public engagement work.

> *124. I think that is very dangerous [upstream public engagement in agenda setting]. There will be people within the group that we call public that will take that role responsibly and will think long and hard about what they do and will make sensible suggestions, but you run the risk of running R and D by current popularity contest and what's been recently in the media and looked like a good idea. You know, if you were to ask 10 members of the public what should we be devoting our energy research money into- I bet none of them would tell you nuclear. It would based on entirely what the last new story was from the last three months or you know, none of them would be wanting biofuels either at the moment, and I think there is a real need to be more impartial than that. (Researcher engaged in public engagement exercises)*

Interpretations of responses to such hypothetical questions should be viewed with caution for a number of reasons, not least due to the ambiguity of what upstream public engagement means and how the interviewee interpreted it. However, despite this, the overwhelming response is suggestive of a prevalence of such an instrumentalist discourse. Where it was felt that public engagement, outside of education and information provision, was necessary, the prescription for such engagement was generally confined to downstream issues. Not challenging the aims and definitions of sustainability defined by policy, this linear view of policy making tended to accept its role as 'sorting out

the facts' and 'building the evidence base' for rational decision making (with or without public engagement) in downstream processes (i.e. quote 125).

> *125.* **Is there a need to interact with the public over more fundamental questions pertaining to bioenergy and issues like the use of GM?**
>
> *I don't now. I think science needs to get its story straight first. That's the job of science to provide the evidence that can then be debated by the public or the politicians. We're not all going to agree but there's core research that still needs to be done about growing these crops and the wider impacts of that on landuse…and we haven't done that research yet, so I think if you get people talking about issues where there isn't scientific basis there for them to discuss, I don't now how valuable that is really. (UKERC member Y)*

The tensions highlighted in the previous section, particularly in the SUPERGEN-Bioenergy and TSEC-BIOSYS projects, appear in some respects to be linked to the widespread positivistic views highlighted in this section. Thus while many viewed engagement with the public (and a consideration of the value dimensions of research in general) as unnecessary, this appeared to also be linked with reservations as to the function and value of qualitative research in general. Whilst there has been some resistance to user engagement in terms of engagement with researcher users in industry and government, there appeared much more resistance to substantive engagement with broader interests. In many cases a demarcation was made between expertise associated with those with economic interests in bioenergy, and other lay interests associated with wider publics. Whilst many interviewees seemed generally comfortable in engaging with industrial sources, engagement with wider interests/publics was generally viewed differently.

Despite the project commitments to public engagement, very few individuals, even within the themes dealing with public engagement, were committed to a normative rationale for engagement. Tensions could thus primarily be seen as existing between instrumental and substantive rationales. While instrumental rationales for public engagement could be seen as reflecting the underlying discourse on science as provider of objective facts for policy making and a

linear view of policy making, practices that are underpinned by a more substantial or normative rationale can be seen to challenge this position. This is because, to varying degrees, these rationales explicitly rest on the assumption that the production of scientific knowledge is political, or has political consequences. It appeared that engaging with industrial and government interests aimed at forwarding a bioenergy industry was more acceptable under a positivistic discourse commitment to scientific objectivity, than substantively engaging with potentially conflicting interests in the wider public sphere. This could be explained by the appeal of the dominant storyline of 'realising the potential of bioenergy', which was referred to almost universally amongst individuals working on the projects. As opposed to engaging with potentially competing interests, 'realising the potential' of bioenergy was treated as apolitical.

Differing epistemological commitments in different disciplines, especially between the natural and more critical social sciences have long been recognised as barriers to interdisciplinary research (Evans and Marvin, 2006), and the tensions between philosophies of positivism and more constructivist perspectives is well recognized and constitutes a long running debate in the philosophy of science. Evans and Marvin (2006) make the case that the fundamental obstacle to interdisciplinary research is the knowledge practices of individual disciplines. More specifically there is a barrier to interdisciplinarity brought about by the perceived threat of the loss of beliefs and identities that constitute different disciplines.

7.4 Impacts of a dominant positivist discourse

The different rationales or discourses around science and the role of public engagement dictates the way that participation in science is approached, and it is clear that there are tensions between the implications of the different perspective in the design of participation (Stirling, 2006). It was evident that the dominance of positivistic discourses around science, while not only leading

directly to a lack of apparent reflexivity on the projects also acted to constrain competing perspectives.

7.4.1 Social science as 'end of pipe' research

The most obvious way that the dominance of positivism has constrained alternative discourses is in the initial construction of the projects and their broad framings of the issues surrounding bioenergy sustainability. Thus, both theme 6 in SUPERGEN-Bioenergy and theme 3 in TSEC-BIOSYS were created after the initial forming of the projects. This is most evident in SUPERGEN-Bioenergy, where theme 6 is perceived by some as a 'bolt on' or afterthought to the engineering aspects of the project (quote 126). Within SUPERGEN-Bioenergy this appears to also have persisted into phase 2 of the project (quote 127). Likewise, much like the systems theme in SUPERGEN-Bioenergy the natural science and social science aspects of the projects were formed quite separately (quote 128).

> *126. this sort of social concept is a bit of an add on, an afterthought, sort of, gosh we better get someone in to do social stuff as well…..Basically the rest of the consortium was formed when they decided that they needed a social input. I don't know whether that was in response to EPSRC feedback (SUPERGEN-Bioenergy member B)*

> *127. theme 6 is still a bolt on [in SUPERGEN-Bioenergy phase 2]. ****** feeds into theme 1 and maybe 5. All the other themes are meant to feed into it, and a lot of the work that ******** does will draw on the work of the other members in SUPERGEN, but does that mean it feeds into other peoples' themes, I'm not convinced. (SUPERGEN-Bioenergy member C)*

> *128. Thinking about it, actually the people who started it off [TSEC-BIOSYS] were mostly natural scientists. I was certainly involved, *****, ******, ******. We all came at it from a very biologically or physically based point of view. The question would be, what biomass*

> *crops could be grown in this country? How much could we produce given a range of scenarios? How much biomass supply could you conceivably get in the UK? (TSEC-BIOSYS member I)*

SUPERGEN-Bioenergy is primarily an engineering based consortium, the primary aim of which is the development of low carbon, efficient bioenergy technology pathways. Thus in both phases of the project all but one of the themes are primarily committed to the objective of bioenergy development. In both phases of the project, assessing the 'other' sustainability aspects of bioenergy have been restricted to one theme that is designed to feed into and co-ordinate research emanating from the other themes. While it appears that theme 6 has had little influence on the conceptualisation of sustainability in other themes, it is clear that the framing of the project as a whole has influenced the framing of the research within theme 6.

The SUPERGEN-Bioenergy consortium has a number of industry partners, whose engagement is principally substantive. That is, their role is to help steer the direction of the research and gain access to early results to come out of the projects, with the primary aim of forwarding the UK bioenergy sector. A similar objective underpins the establishment of the 'Bioenergy Funders Forum', set up with the aim of engaging the bioenergy industry with agenda setting within bioenergy research in the UK. As part of SUPERGEN-Bioenergy 1, the project also ran a number different broader 'stakeholder engagement' exercises around particular bioelectricity case projects and regional bioenergy scenarios. Various exercises are also planned for phase 2. The intended outcomes of these exercises are less clear-cut, and the overall rationale appears to have been more contested. However, it is clear that the original proposal, written with the intension of 'optimising the allocation of biomass resources', constrains the ways in which public engagement can be thought about (quote 129). It is clear that in this case the framing of the project under the assumption of there existing an optimal allocation of biomass resources depoliticises many of the issues around bioenergy, and the explicit commitment to forwarding a bioenergy industry has direct consequences for public engagement (quote 130).

129. We have specific objectives…...to come out with this optimal allocation of this global biomass resource for 2020 bioenergy and different people buy into that to different extents. I think most people do buy into it actually; ……I really don't agree with the idea of an optimal allocation because different people have- there's no one optimal allocation, whereas the case of support was written with the concept of an optimal allocation in mind. (SUPERGEN-Bioenergy member A)

130. SUPERGEN has a pro-bioenergy mission to advance bioenergy explicitly on its website and that is a real problem in engaging with stakeholders who are critical of bioenergy. And we've had to go to considerable lengths to persuade them and we haven't succeeded wholly that some of us are impartial (SUPERGEN-Bioenergy member A)

Within SUPERGEN-Bioenergy it is obvious that the majority of resources are committed to the objective of forwarding a bioenergy industry, and given that the two objectives appear to be not entirely compatible, the critical nature of the second objective appears to have suffered under the dominant framing. This is a result of funding practices that both see energy as primarily an engineering issue and social sciences as primarily 'end of pipe' disciplines. These tensions over the normative objectives of the project appear to have persisted into phase 2 of the project. This demonstrates how traditional understandings of science that see social science as fulfilling an end-of-pipe role in terms of managing the outcomes of science (rather than functioning further upstream in agenda setting) have become institutionalised in publically funded research. While representing the potential to democratise science, under positivistic discourses, practices such as interdisciplinarity can be seen to function to constrain different discourses over the social role of science.

7.5 Administrative rationalism and positivism

As demonstrated in the previous three sections, much of the discourse around bioenergy and sustainability assumed a very linear view of policy making and a very separate role for science in society. Whilst the interviews were suggestive of a number of different environmental discourses, there was more of a united administrative perspective on the role of science in sustainability and in society more generally. Administrative rationalism in this sense can be viewed as associated with, or as an extension of, a very positivistic epistemological position regarding the role of science and the status of scientific knowledge. Apart from its preoccupation with centralised management in general, administrative rationalism has an extremely hierarchical conception of social order.

While there appeared to be an underlying assumption that bioenergy would lead to greater sustainability in the energy sector, when questioned further many interviewees were unsure about the likelihood or feasibility of implementing effective regulation to cover international bioenergy trade in bioresources. In this way, while support for biofuels appeared associated with the view that it was technically possible to construct a system of international accreditation, the feasibility of actually implementing such a system was often not considered to be as relevant. This is maybe more suggestive of a commitment to positivism than administrative rationalism more broadly. It is possible that much of the administrative narrative in the interviews reflected a natural extension of the positivism associated with the interviewees understanding of science. The degree to which the observed administrative rationalistic narratives seen in the interviews are predicated upon or related to the positivism evident in individuals views on the role of science in society is unclear. However, it may be that the difficulty the author of this thesis had in allocating individuals to specific discourse types (see chapter 6), reflects this association. While many individuals appeared committed to a discourse of administrative rationalism, many also drew on multiple discourse types. The three quotes below are from the same interview and highlight the recourse to multiple rationalities. While in quote 131, the interviewee appears to assume a certain degree of political

efficacy in regards to regulating the sustainability of the industry, quote 132 suggests the opposite. Despite these views, the interviewee stayed resolutely committed to the fundamental sustainability of bioenergy as a technology (quote 133).

> *131. We'll be likely to be importing bioethanol from Brazil, they'll double their export capacity and that's one of the most efficient biofuels that we can buy; so that import will go on and we're likely to decrease our imports from non-sustainable sources. So all of those things will probably happen over the next 10 years. (TSEC-BIOSYS member D)*

> *132. we have known for 10 years that cutting down the tropical rainforest contributes 20% to the greenhouse effect but we haven't been able to do anything about that at a geopolitical level. My fear is with trade in biofuel is that the same thing may unravel at the moment.*
>
> **But it will be a necessity, for any sort of sustainability criteria for growing crops is the ability to regulate the trade of it**
>
> *You and I can sit in this office and say that it is a clear necessity to have that; how that happens, I mean we've seen the way those global trade talks go on for years and years. So I think that's really hard to predict what's going to happen… And it's critical, again. (TSEC-BIOSYS member D)*

> *133. So I can talk until I'm blue in the face about the sustainability of biofuels, but if someone has read the latest edition of the daily mail, that's not going to be very convincing necessarily. (TSEC-BIOSYS member D)*

While the last quote above no doubt represents to some degree the strategically ambiguous use of the sustainability term, given that the first two quotes above are suggestive of very different discourses, it also appears to reflect something more. As well as using sustainability to mean a number of different things, it is clear that it is also used under a number of different rationalities. Scientific discourses do not function in isolation. Instead, through a process referred to as

interdiscursivity, they draw upon, interrelate, compete and struggle with other discourses in order to both represent and also constitute science-orientated knowledge (Motion and Doolin, 2007). A useful way to analyse this interdiscursivity, is to consider how discoursing subjects legitimate particular discursive positions through the construction of particular identities for themselves and for others. Just as scientists draw on multiple discourses when contextualising their work, they also simultaneously engage in identity construction through discourse, both as individuals and as members of multiple social groups, categories and communities (Ainsworth and Hardy, 2004; Fairclough, 1995). However rather than thinking of identities as singular or fixed, identity can be more usefully conceptualised to involve what Davis and Harre (1990) refer to as the 'discursive production of a diversity of selves'. Identities in this way should not be considered to be static, or even necessarily complimentary. The multiple positions that individuals may hold may be contradictory, as discourses may conflict or compete. It thus appears that in drawing on different rationalities, many individuals in the interviews may have been moving between identifying as scientists, and identifying as other.

In discussions over their work many individuals drew on very administrative tropes, while in more abstracted conversations over the meaning of sustainability, a greater range of discourse types were utilized. The individuals quoted below (quotes 134-136) all made recourse to a very administrative type discourse when talking about contributing to the sustainability of bioenergy or the broader energy system. However, while making claim to the sustainability of bioenergy, drawing on more radical discourse, they also lambasted the unsustainabiltity of the system in which they carried out their work.

> *134. I don't think we're dealing with the real sustainability issues in the world, I just don't think we are. And I don't think we will, I don't think we've got the capability…….. We will carry on pretending to move towards a sustainable society without actually doing it. (RELU-Biomass member)*

135. until we start to get to quite different economic models it's very hard to see how we can have sustainable development (TSEC-BIOSYS member)

136. thinking that a very slight tweaking of the status quo makes it sustainable is nonsense…there are certain things we do and we want to carry on doing them as we are, but it may be crazy to do it, but we think that if we just change the edges a bit, that will make it sustainable, more sustainable and we can easily delude ourselves. That's the problem with the misuse of the word sustainable. (TSEC-BIOSYS memeber)

Below are three quotes from the same interviewee concerning the sustainability of bioenergy. While in the first two quotes (quotes 137 and 138) the sustainability of a particular technology is definitively stressed, the third quote (quote 139) seemingly contradicts these positions. The third quote also draws attention to the tendencies and limitations of quantitative science in considering the sustainability of bioenergy.

137. I think the rest can all be managed from a sustainability perspective; we can look at the fact that for bioelectricity we will get a 90% reduction in carbon if we switch to biomass and that's great. And to argue that that isn't sustainable would be nonsense. You now, that must be sustainable.

138. I actually think that co-firing is environmentally very sustainable.

139. There's a real need to do it [look at the global land picture], no one is doing it because it's too big, it's too difficult and the data isn't there. So we put it to one side and ignore it. Without doing that we can't possible say what's really sustainable in the long term, in terms of international problems. (senior researcher in environmental theme)

Conclusion

While the previous chapter explored the way that research has engaged with the debate over the sustainability of bioenergy, this chapter has explored the potential factors shaping this engagement. Despite the variety of views on bioenergy within the projects, in many ways these initiatives reproduce much of the discourse underpinning the dominant ecological modernistic discourse of energy policy and many of the storylines and assumptions used by the pro-biofuel coalition. This chapter has highlighted the functioning of two broad factors that have acted to constrain the way that the projects have engaged with the issue of bioenergy sustainability. The first of these is directly related to the dominance of ecological modernisation and its institutionalisation of a particular conception of relevance in science. This is most obvious in practices of agenda setting and the structuring of funding around strategic policy objectives. However, it is also apparent that practices such as interactivity and interdisciplinarity are also influential. While interaction within the projects has primarily given voice to interests based on economic criteria, it is also clear that in some instances, practices such as interdisciplinarity have acted to silence alternative discursive commitments within the projects , that might, in other circumstances have led to an 'opening up' of the debate around sustainability.

The second factor acting to constrain engagement with sustainability is arguably the existence of a strong positivism within the projects. Thus while happy to use the term sustainability, it was clear that the concept was widely viewed as having little relevance within science. This was also evident in both its cynical use in applying for funding and in the lack of discussion within the projects over its definition and application. For many, it would appear that the assumed apolitical nature of science deems the potential political function of the projects, in terms of the questions they ask and the way they present and contextualise their research, irrelevant. For example, with regard to the project websites, while the majority of individuals saw these as important media, there was also a lack of knowledge over their content. While the maintenance of these sites was controlled by a few people, the majority of seemed unconcerned as to the exact content of the sites, seeing it as not particularly of their concern. While interest

in the websites was no doubt constrained by time and resources, it thus also appeared restricted by a particularly instrumental view of public engagement. It was also clear that the ambiguous use of the sustainability concept within the projects may have also played a role. For example, while it was obvious that many individuals held radically different views on the sustainability of bioenergy, there was also a feeling that 'people had a common understanding of what sustainability meant'

The positivism identified on the projects is likely associated with the prevalence of an administrative rationalism, identified in chapter 6. This discourse is optimistic as to the potential for humans to manage the environment. As such, it can be seen as being associated with very prescriptive accounts of the potential for bioenergy. Discussions over bioenergy were thus generally framed in the language of technical and regulatory potential, rather than risk and precaution. Most importantly however, it is extremely hierarchical in its conception of the social order, thus resonating with the underlying positivism and providing a conceptual framework for the separation of science from society. It was clear that while stressing the sustainability of bioenergy, many individuals drew on multiple conflicting rationalities, and it is possible that the prevalence of administrative rationalism within the projects reflects the roles individuals have taken up and the identities assumed as scientists in the context of the projects. While administrative rationalism is much more proscriptive in its desire and assumed capacity for humans to comprehensively manage their environment than ecological modernisation, the ambiguous storyline of 'realising the potential of bioenergy' appeared to resonate positively with most project members. This may be because of its (superficially) apolitical tone. While preserving the perceived autonomy and objectivity of science is important for preserving the authority of scientists, it is also important for any government drawing its authority from evidence-based policy making.

Chapter 8. Discussion: Science for sustainability

The aim of this chapter is to bring the finding presented in the previous four chapters into a general discussion over the role of science in the politics of a sustainable bioenergy. While these previous chapters have already provided a certain amount of analysis and context to the data collected as part of the methodology, this chapter is designed to put this analysis into perspective regarding the primary aims of this thesis. The chapters will be linked with a general discussion over the relationship between science and the wider politics of bioenergy.

8.1 Reinforcing discourses

A primary conclusion of this thesis is that in many respects, publically funded bioenergy research, as represented by the projects, does much to reinforce the dominant ecological modernisation discourse governing bioenergy policy. By focusing on least cost decarbonisation, national social and environmental issues and reproducing a number of storylines associated with the pro-biofuel coalition, it also fails to address what many would see as the primary sustainability concerns associated with biofuels. This insight is supported by the quote below (quote 140), from a senior member of TSEC-BIOSYS.

> *140. There's two sorts. There's technological optimism among non-engineers, ******* is one of the worst, ******** pretty close behind him. Both seem to think climate change is a technological problem. Now if they were engineers they'd know otherwise. The other end of the scale, there's an awful lot of enthusiasm in the engineering community for the technical challenges of producing second generation biofuels. And I think the enthusiasm for second generation biofuels is by a large extent driven by the engineering community who regard this as a useful and important thing that they can be doing, without stopping to think about whether they ought to be doing it in the first place. (TSEC-BIOSYS member)*

While many individuals within the projects are committed to forwarding a 'sustainable' bioenergy sector, the current controversy over biofuels (and by extension, any other bioenergy technology) raises many questions over the role of publically funded research in the politics of a sustainable bioenergy. As was discussed in the previous chapter, despite drawing on various discourse types, especially when discussing their science, individuals primarily drew on very administrative tropes. It is also apparent that this administrative rationalism, to some degree, reflects an underlying commitment to positivism regarding the nature of science and the perceived need to maintain a clear separation between science and politics. Although more focussed on issues of technological efficiency and with accompanying visions of idealised bioenergy futures, the storyline of 'realising the potential of bioenergy' seems to resonate with these commitments.

In stressing the independent and objective nature of the research being conducted, most individuals within the three energy programme initiatives also held very instrumental views on wider public (interest) engagement. The perceived apolitical nature of the projects appeared to negate the necessity for any discussion (outside of those themes concerned with sustainability appraisal) of sustainability. Despite this, 'realising the potential of bioenergy', whether it involve technological potentials, or economic optima, appeared to be widely regarded as an apolitical agenda. In ascribing to similar storylines of progress, optimisation and a desire to realise the potential of bioenergy (although maybe different conceptions of what this means or entails in terms of regulation etc.), both energy policy and bioenergy science reproduce similar understandings of bioenergy.

The mutual support these two discourses types provide has been recognised in other science policy areas, most notably in research looking at climate governance. Here, Backstrand and Lovbrand (2008) demonstrate the mutually constitutive roles played by administrative and market-based discourses in complex governance issues. Whilst they use a slightly different, broader typology, describing the convergence of 'green govermentality' (associated with strong government administration and big planetary science) and weak

ecological modernisation, the insights are similar. Within the bioenergy community, the 'realising the potential' storyline is useful for both government and science. Just as the government relies heavily on the existence of an 'objective' and 'sound' science with which to legitimise the enactment of evidence-based policy making, so the administrative discourse dominating science requires this separation to maintain its own authority. Both are invested in the maintenance of a very linear view of policy making (Gieryn, 1995; Jasanoff, 2004).

8.1.1 Polarisation of the debate

While many individuals within the projects disagreed with government policy on biofuels, it also appears that the rapid polarisation of the debate over biofuels may have further reinforced the relationship between science and policy. Much of the opposition to biofuels appears to stem not from a rejection of the technology, but from disillusionment with the context of its development (including the construction of scientifically defined standards in partnership with industry). As such, many organisations are now calling for a moratorium on biofuels (.g. Oxfam, 2008**;** JRC, 2008; HoC Environmental Audit Committee, 2008; EEA, 2009). Despite varying views over biofuels within the projects, given the negative reporting on biofuels in the media over the past few years and the 'apolitical' focus of the administrative rationalist discourse on realising the potential of bioenergy, it appears that many individuals within the projects felt driven into defending biofuels as a technology choice; seeing themselves in many ways as responsible for the success of the technology. The defensiveness towards bioenergy also appears associated with a characterisation of opposition to biofuels as in many ways anti-science, or at least irrational. This pro-active defence of bioenergy is again evident in the two quotes below (quotes 141 and 142).

> *141. I'm often in television interviews, head to head with the guy from Greenpeace (TSEC-BIOSYS member)*

142. (industry) is one area where it is very important to engage and the other area is in debunking myths and public engagement, cos there's a lot of nonsense that you can read about or hear about in the area of bioenergy, mostly based on the fact that whoever produces it is taking either a biased perspective or a superficial perspective. So it's actually trying to put together a more comprehensive explanation, which is still easy to understand, can be quite a challenge but I think that's very important when you've got a fledgling industry, to get those sort of messages across. (TSEC-BIOSYS member U)

Post-structuralist theories of discourse, such as used in this thesis, conceptualise personal interests as in dialectical relationship with ones discursive affinities. That is to say that in many ways, while ones worldviews or understandings of the world are dependant upon ones interests, ones interests are also dependant on ones particular understanding of the world. While it is thus difficult to draw conclusions about causation, there was some evidence to suggest that the very involvement of individuals in this type of research influenced their commitment to bioenergy as a technology choice. A certain 'defensiveness' in regard to bioenergy technology was described by one member of the RELU-Biomass project, who put the behaviour down to feelings of responsibility for those industry interests with whom the researchers interacted (section 7.1.4). The quote below (quote 143) also highlights a major concern within the bioenergy community; that public concern over biofuels will spill over into discussions over bioenergy for heat and electricity.

143. There are some serious issues with biofuels, both with the public conception of them is one of them, that there is a real risk that bioenergy development could be stalled if the bad press that biofuels is going to get, if people connect the two, which realistically they are connected because some of the fuel sources are the same, you can theoretically eventually use wood. (TSEC-BIOSYS, member T)

Whilst public opposition has so far focussed on biofuels, an increasing amount of biomass for electricity and heat is being imported in to the UK. In response to the opposition to biofuels policy it is now likely that in the future, sustainability standards will be extended to include biomass for other purposes (CEC, 2009).

This will happen rather than any direct restriction in trade. In response to projections made for the Renewable Energy Roadmap, there have been calls to widen the sustainability scheme proposed for biofuels to biomass as a whole. In late 2008 the European Commission launched a consultation concerning the need for sustainability criteria for energy uses of biomass other than transport. The consultation reported strong support for a sustainability scheme for bioelectricity and heating, concluding that an exclusive limitation to sustainability criteria for transport purposes was not reasonable (CEC, 2009). While there are not yet sustainability standards for biomass for heat and electricity, the UK government recently announced the necessity of such a development (HM Government, 2009b). Reporting on sustainability for biomass within the RO was introduced in April 2009 (Order 2009 SI No. 785) and Ofgem will report in 2010 (HM Government, 2009b). Given the current controversy over biofuels, whilst abrogating responsibility for sustainability onto science and the designing of scientifically defined standards may deflecting some potential challenges it is unlikely to satisfy those that have problematised the scientisation of risk within biofuel policy.

8.1.2 Negotiating Boundaries

The combined recourse to scientific neutrality and objectivity, and active advocacy of bioenergy, highlights the potentially ambiguous and movable boundaries between science and society. Much of the discussions in the previous chapter highlight the existence of a certain amount of boundary work within the context of the projects. While much effort went into rhetorically separating science from politics and stressing the objectivity and independence of research, it also appeared that many individuals felt the need to educate the public about the necessity of bioenergy. This is evident both in the interviews and as a result of the website analysis. Although this boundary work is evident throughout the previous section, an example is also provided in the extended quote below (quote 144).

144. **And what is the general purpose of this interaction [on the project]. It probably does vary. Is a lot of it communicating your research to a wider public?**

Yes, in general terms. So again, it's telling the story. Some technical specialists aren't very good at doing that, they find that difficult and actually they don't want to do it, and some people will have a more outfacing approach and can do that. Can not only do that, but enjoy that and see it as essential part of their life in public service. So, for me, you now, I am in the wider sense a servant of the tax payer because it's tax payers money that funds what I do. So I would say that it is equally important part of my role to disseminate what I do back to the public whenever I possibly can. And that's usually using quite a lot of my time for free, that it's part of the role, the outfacing role of the university and of scientists in general. So probably if I worked for a commercial company, I wouldn't be able to justify that time.

With regards to NIMBYISM and maybe the press, I don't now, I mean, is there a need to engage the public on a more fundamental level about bioenergy maybe the way they did with GM crops?

But that was really too little too late, we failed with GM crops

Is that something you could see happening in bioenergy, unless that engagement

Yep, so that sort of engagement is lacking and it is already happening in bioenergy. And you know, you look at organizations like RSPB and they have an appalling set of propaganda really on their website. Their latest leaflet on biofuels actually makes the statement "is this the first bird to be made extinct by biofuels". I have a copy here actually, and I was proudly given that at a recent bioenergy meeting and, you know, I questioned those guys and said, "well, why are you making those claims, what's the evidence for that?" and they said, "well, we are a campaigning organization". So the public is looking for reliable sources of information, they don't read the sort of technical documents of course that are available and so, you now, they can get a very biased opinion about some of these complex scientific issues. GM isn't going to go away, I mean, you know, we're applying for several trials in Europe right now to grow GM trees, and it will be interesting to see what happens to those. (TSEC-Biosys member, D)

This quote is interesting for a number of reasons, not least because of the analogy with GM. The interviewee here stresses the necessity and resulting inevitability of technologies such as biofuels and GM. However, while recognising the failure of engagement in the case of GM, the failure here is not attributed to the instrumentality of the process, recognised by much post hoc. analysis (i.e.. Horlick-Jones et al., 2006), but rather to the failure to persuade the public that they did want GM in the first place. As opposed to the 'biased' information on the desirability of biofuel peddled by campaigning organisations such as the RSPB, the public are in need of 'reliable (scientific) information' as to the necessity of biofuels.

Concern over the public being 'misinformed' about biofuels by NGOs and media sources was widespread within the projects. To this end many individuals appeared to see themselves as obliged to counter such mis-information, through reiteration of the potential benefits of biofuels. While a number of individuals (mainly those who didn't want to see biofuel expansion) thought that media and NGOs commentary had played an important function in highlighting the dangers of biofuels, many interpreted these inputs as irresponsible and in need of counter argument (quote 145).

> *145. Only 1% of palm oil coming out of Indonesia goes into biofuels, the other 99% goes into hobnobs, well food or products….i think it's the Searchinger paper that set everyone up into arms about that one, about him suggesting that biofuels have no benefits……He published a paper saying that corn ethanol in the UK would increase the GHG emissions for the next 167years…..there was a lot of comeback on it, saying that you haven't taken into account yield. That's the thing, we have no system for working that one out at the moment within the LCA and the NGO's whether or not, I mean I debate …how much value there would be to actually do that, because there would be so many assumptions in the model, but the NGO's will always use that as an Achilles heel to knock down biofuels and biomass because we don't have anyway to answer that accusation, so we need some way of looking at that. (TSEC-BIOSYS member T)*

While there was evidence of much effort to dissociate the research conducted on the case-projects from their political dimensions, this was often coupled with a perceived need to 'educate' the public as to the desirability of bioenergy. Given the negative reporting on biofuels in the media over the past few years, many individuals also appeared to feel responsible for defending bioenergy as a technology choice. This combined recourse to scientific neutrality and objectivity, and active advocacy highlights the potentially ambiguous and movable boundaries between science and society.

8.2 Bioenergy for sustainability

The current debate over biofuels bears many resemblances to previous and in many cases ongoing public controversies over other technologies; the most obvious of these being genetic modification of crops and nuclear power. The genetic modification debate bears particular relevance to the current debate over bioenergy, due to the obvious direct linkage between the two. Crops have never been selected and bred for their amenability to be used as a fuel. While genetic modification (GM) of bioenergy crops has not become a point of serious public debate as of yet, it is clear that given the seeming commitment in parts of the science community to genetic modification (see section 7.3.3) as an essential component of a bioenergy future, that this represents a potential conflict; an issue already recognised by some in the bioenergy community (personal communication with member of TSEC-BIOSYS).

Much of the historical conflict over GM crops (e.g. Wynne and Meyer, 1993) and nuclear power (e.g. Irwin and Wynne, 1996) concerned the way that risk was conceptualised by the dominant interests as a scientific issue (see chapter 2), and the way that the public and other stakeholders with concerns over these technologies were concurrently conceptualised as irrational, overly emotional and short-sighted as to the benefits of such technology. While exercise such as GM nation were designed to counter public opposition to GM, in this case, the instrumentality of such engagement became obvious when it was clear that the Government was already committed to GM technology. This pre-commitment to

GM and the resultantly instrumental approach to engagement was proposed as one of the reasons why engagement over GM failed (Mayer, 2003).

The 'scientisation' of technological risk is evident again in the debate over biofuels, as is the cause of concern; namely the perceived motivations of government and industry and institutional trust. While there has been little meaningful public engagement over biofuels and bioenergy in general, the dominant discourse appears to regard opposition to biofuels in much the same way as it did GM and nuclear power. It also appears that the risks of bioenergy are again to be regulated primarily through scientific assessment, with the onus being on proving the unsustainability of certain practices, rather than the adoption of more precautionary approaches. As discussed in chapter 5, the scientisation of environmental policy is institutionalised in international bodies such as the World Trade Organisation (WTO). WTO rules require that nations can only restrict trade on the basis of scientific risk assessment. Being designed to ensure more open flow of goods, these rules give precedence to economic values over all others. Despite this, it has been repeatedly demonstrated that public opposition to things like GM foods have little to do with scientifically determined levels of risk (e.g. Mayer, 2003; Sarawitz, 2004).

While many of the risks associated with bioenergy and GM are different, in that those relating to bioenergy are generally more diffuse and global, much of the debate is similar. Scientisation is again being used to suppress the open discussion of value preferences and alternative frames of reference. Global trade in bioresources and the interaction of bioenergy with other global commodity markets means that, while the impacts of bioenergy may very well be both positive and negative, the costs are likely to be experienced disproportionately by certain sections of the global community. This raises a number of more complicated moral questions, and puts the question of problem-framing and definitions of sustainability very much at the heart of the debate over bioenergy. While developed explicitly within a context of sustainable development and climate change mitigation, its interaction with other 'sustainability' issues, such as water access, land tenure and biodiversity loss, highlights the importance of problem-framing when discussing bioenergy.

The concealing of preferences and values behind technical argument is actively supported by the enduring social commitment to the idea of scientific facts as detached from values, and the linear view of science (Lovbrand and Oberg, 2005). Not only does the scientisation of the debate over bioenergy legitimate only those problem frames ameanable to scientific study, but it also empowers those entrenched interests that have the resources for, or control over research funding. While this thesis has focused on what are arguably the three primary issues of GHG emissions, competition with food and competition with nature conservation, there are a number of other issues that while attracting less attention, have the potential to become points of conflict within the bioenergy debate. As well as these direct and indirect socio-environmental impacts, it is also possible that bioenergy may have more diffuse, less obvious implications for sustainable development. For example, while opening up many possibilities for decentralising energy systems and bringing greater coherence to the way we deal with waste, energy and the environment from a policy perspective, there is also the danger that bioenergy could lead to 'technological lock-ins, in both transport and agricultural sectors that might restrict wider transformations within these sectors (Charles et al., 2007). Bioenergy sources that are blended with fossil fuel sources such as co-firing and biofuels may extend the window of fossil fuel use by drawing public and scientific attention and money away from alternative socio-technical arrangements. By extending our current energy systems, we may fail to tackle more fundamental issues and develop strategic technology niches that could transform the energy system (Charles et al., 2007).

8.3 Science for sustainability

It is clear that the struggle over the sustainability of bioenergy is complex and encompasses a wider struggle over the definition of sustainable development and modernity in general. This dimension of the debate however is obscured by the strong focus on climate change and life-cycle analysis of GHG emissions. Whilst there is struggle over the framing of the debate, it is also clear that rather

than making matters clearer, the production of more science may actually be making matters worse and obscuring some of the more important value conflicts underpinning the debate. Over the past 15 years or so, a number of prescriptions for a science more orientated to the goals of sustainable development have emerged. While there has been a trend in science policy over the last 30 years or so toward more problem focused research agenda, a common feature of these 'prescriptions for sustainability' is the need to marry this drive for greater salience with a wider accountability. However, the drive for a more problem focused research agenda, and the drive for a more legitimate and democratically accountable science are deeply entangled and in many cases in tension (Kates *et al.*, 2001).

8.3.1 Legitimacy and public participation

In response to the perceived 'capture' of science by powerful economic interests, there have been many calls for a more transparent and democratically accountable science (i.e. Lubchenco, 1998; Gibbons, 1999; House of Lords Science and Technology Select Committee, 2000; Gallopin *et al.*, 2001; Kates *et al.*, 2002; ICSU, 2002; ICSU, 2005). Probably the most recognisable prescription for a science for sustainability is the new 'meta-discipline' of 'sustainability science' (Kates et al., 2001) which emerged around the formulisations for the World Summit on Sustainable Development (WSSD) in 2002. Within sustainability science, science is seen as needing to change dramatically from its traditional role in knowledge production, both in the questions it asks and in the way it operates. S&T should thus become an enterprise committed to empowering all members of society to make informed choices, rather than providing its services only to powerful groups (whether states, multinationals, or international organizations) that can most readily pay for or otherwise command its services (ICSU, 2002).

Under sustainability science, S&T for sustainable development is expected to be clear about what goals, and whose goals, it is trying to advance. As such it should be for achieving social goals, solving problems, empowering people, and

promoting social learning (ICSU, 2002). As well as directly broadening participation in S&T, sustainability science should also aim to be more transparent, politically relevant, holistic and fundamentally inter-disciplinary in its methods. Other key issues are: the promotion of gender equality within science, the bridging of the North-South divide in scientific and technological capacity, and the normalisation of a greater role for indigenous and traditional knowledge (ICSU, 2002).

The rationale for this emerging field broadly reflects much of the thinking that has characterised other prescription for a more 'sustainable' science that has emerged over the last 20 years (e.g. Citizen science, (Irwin, 1995); civic science (Lee, 1993); appropriate science (Wynne and Mayer, 1993) and democratic science (Brown, 1998). However, there are important differences between these proscriptions. As an example, while superficially similar, post-normal science has very different rationale. Although superficially similar to sustainability science in its prescription for a more problem focused and legitimate science, post-normal science (PNS) draws its rationale much more explicitly from science studies and the sociology of scientific knowledge. 'Normality' in PNS is used to describe a pre-Kuhnian (Kuhn 1970) view of science and a view of a policy environment as adequately served by puzzle solving experts alone. The argument is that, the conditions under which science and policy are conducted can no longer assume this normality. The insight leading to post-normal science is that the sorts of issue-driven science relating to environmental debates, typically facts are uncertain, values in dispute, stakes high, and decisions urgent (Funtowitcz, and Ravetz, 1993).

Assuming an explicitly more constructivist approach, PNS propounds that 'sound-science' invoked as necessary for rational decision making may affectively conceal value-loadings that determine research conclusions and policy recommendations. In these new circumstances, invoking 'truth' as the goal of science is a distraction, or even a diversion from the real task. A more relevant and robust guiding principle is quality, understood as a contextual property of scientific information (Ravetz, 1996). Quality refers as much to process as to product. In complex environmental issues, lacking neat solutions

and requiring support from all stakeholders, the quality of the decision making process is absolutely critical for the achievement of an effective product in the decision. This applies to the scientific aspect of the decision as much as to any other (Wynne, 1992). PNS's theoretical core is the task of quality assurance, in that it argues the need for new methods, involving 'extended peer communities' for deploying 'extended facts' (Ravetz, 1999). While sustainability science focuses on the need for wider participation in science policy and agenda setting and the recognition for better and more democratic use of scientific knowledge (through changes in governance structures), post-normal science places more emphasis on the interrogation of expertise and the subsequent need for more emphasis to be placed on the co-production and validation of knowledge. This reflects its much more constructivist roots, and deeper 'problematisation' of the inherently political nature of scientific knowledge. While sustainability science and post normal science are both concerned with procedure, post-normal science is less prescriptive of what science needs to be done, and therefore has little to say about actual research agendas.

Sustainability science proposes that science must be sufficiently reliable (or credible) to justify people risking action upon it, sufficiently relevant (or salient) to decision makers' needs and sufficiently democratic and respectful in its choice of issues to address, expertise to consider and participants to engage (i.e. socially and politically "legitimate"). However, it was also recognised that these qualities are tightly interdependent, and that efforts to enhance one, may often undermine the others. It is thus concluded that this interdependence poses substantial challenges to the design of institutions for mobilizing R&D, assessment and decision-support for sustainable development (ICSU, 2002)[13]. The emphasis put on each of these qualities (or the degree to which an emphasis is put on increasing legitimacy) by different approaches to a science for sustainability, depends very much upon the conceived nature of scientific

[13] In the sense used here, credibility involves the scientific adequacy of the technical evidence and arguments. Salience deals with the relevance of the assessment to the needs of decision makers. Legitimacy reflects the perception that the production of information and technology has been respectful of stakeholders' divergent values and beliefs, unbiased in its conduct, and fair in its treatment of opposing views and interests (Cash et al., 2003).

knowledge and expertise. The relationship between these agendas and the extent to which they are perceived to be in tension with one another is partially dictated by the degree to which one views science as embodying certain interests and values, and ones particular conception of knowledge, power and its relation to social change.

Despite the tensions between the different prescriptions for a science for sustainability, they all recognise the current hegemony of (narrowly defined) relevance and the impact that this has on wider aspects of legitimacy. They are all therefore concerned with the need for a science, or knowledge system, that is more aligned with the interests of a broader set of social interests; that is, consistent with a broader democratic rationale. To this end, both interdisciplinarity and interactivity are seen as tangible goals in a more sustainably orientated science[14]. However, as has been demonstrated, just because something is interdisciplinary or interactive, does not automatically ensure that the outcome of the research process will challenge entrenched interests, or lead to a more democratic representation of interests. Likewise, how and when research should engage with these concepts is most likely context dependant and certainly disputed. Although there would seem to be a wide agreement on the direction for change within prescriptions for a more sustainably orientated science, there is therefore somewhat of a lacuna in these prescriptions with respect to how the tangible practices of science have to change, especially in order to accommodate democratic participation (Backstrand, 2004) and broader accountability. Many of the implications for scientific practice and knowledge production are left unanswered, namely how norms, institutions and procedures in science have to change to enable broader participation.

Whilst practices such as interdisciplinarity and interactivity have the potential to transform science into a social enterprise that is more accountable and reflexive, as discussed already the relationship between the two is not

[14] Interdisciplinarity and interactivity are themselves not resolutely defined, and many see interactivity with non-academics as an natural extension of interdisciplinarity; also refered to as ‘transdisciplinarity’.

straightforward. The real struggle appears to lie in the assumptions and rationales underpinning these practices. Or, as articulated within sustainability science, as between relevance (under a prescribed instrumentality) and legitimacy. As discussed above and in the previous chapter, the drive for a (narrow) relevance in science is underpinned by a belief in a fundamental separation of science and politics and a linear view of scientific policy making. In this vain it is argued that in order for a more accountable science, it is central to engage scientists in a critical self-confrontation as to the provisional nature of scientific research and the cultural assumptions underpinning the linear model of science (Lovbrand and Oberg, 2005). To challenge rather than reinstitute the separation of science and politics should be seen as a way towards a more socially accountable and reflexive scientisation (Beck, 1992) of environmental policy.

8.3.2 Evaluating science for sustainability

Sustainability science, citizen science, post-normal science and all of the other proscriptions for a more socially and environmentally considerate science are not rationales that apply only to a certain fields, they are proscriptions for any science that is involved explicitly or implicitly in socially and environmentally contentious issues. Despite the amount of science and technology development being conducted in the context of sustainable development, there appears little dedicated effort committed to reflexive analysis, particularly in the context of current theories of social change. While there are a small number of published studies involving the evaluation of effectiveness in partnership and community based research projects (e.g. Rowe and Frewer, 2004) and certain aspects of SD research projects (e.g. the effectiveness of boundary organisations (Clark et al., 2003) and the effectiveness of participatory techniques (Blackstock et al., 2007)), very few attempts have been made to explicitly explore the role of particular research initiatives in the broader politics of controversial issues. There is also a lack of literature evaluating whether the stated benefits of participatory approaches for sustainability science are achieved in practice (Blackstock et al., 2007).

One of the reasons why this thesis takes a discourse-analysis approach, rather than attempt a more detailed evaluation of particular scientific practices is that the science of interest was not designed specifically to be regulatory, and as such, was not tied directly to bioenergy policy. The role that science should play in sustainable development is, like sustainable development itself, contested. As such, there is somewhat of a lacuna in the thinking about how science needs to change in terms of its organisation and more specific practices (Backstrand, 2004). However it has been suggested that an influential role for research might be to engage with the broader aspects of an issue and challenging the way it has been framed in decision-making communities (Scott, 2004). By taking a discourse analysis approach this thesis attempts to give a broader picture of the role of research-council funded science in the context of this particular controversy.

While this thesis takes a discourse-analysis approach, the position taken is not one of complete relativism. Thus, although conflict over the definition of sustainable development is recognised, sustainability is not taken as an empty and meaningless concept. Importantly, in drawing its conclusions this thesis is based on the assumptions that as well as aiming to reconcile environmental protection with human needs, that science for sustainability should aim to empower individuals in the spirit of social equality. In recognising that scientific practice should aim to empower those whose interests are currently subjugated, the normative aims of sustainable development thus resonate with the normative aims of discourse-analysis.

Sustainable development is now the dominant paradigm of development, and while it reflects a broad political consensus, it nevertheless remains a highly contested concept. Sustainable development has thus become the context for a broad range of social actions, often representing conflicting rationales. Mainstream conceptions of sustainable development have been criticised for attempting to reconcile sustainability with key elements of the dominant neoliberal agenda (e.g. Redclift, 1987). In this worldview, the main cause of environmental degradation is poverty and uncertainty, which can be overcome

by economic growth, increased education of the developing world and an emphasis on technological fixes for environmental problems. However, this conceptualisation contrasts radically with that of many who view unbounded growth, increasing technologisation and political disempowerment as the very causes of unsustainability.

Just as there are various interpretations and discourses of sustainable development, so too are there various understandings of the role science should play in sustainable development. While it can be concluded that, like sustainable development more broadly, there can be considered to be no 'one' science for sustainability, this doesn't mean that the concept is meaningless. Although sustainability does not prescribe what role science should play in its agenda, it does force science to at least engage with its normative aspirations. Sustainability commits science to engage explicitly with issues such as social equality and environmental protection, and also with the various perspectives of what these concepts mean for science.

As has been observed in the projects studied in this thesis, the differing perspectives represent contrasting visions of the desired form of interdisciplinarity and interactivity needed in a science for sustainability, and the underlying rationale for engaging in these activities. While the dominant discourse conceives as the 'gap' between science supply and policy demand as the primary issue in a sustainability context (calling for a more policy relevant science), for others it is the closeness of this relationship that is problematic (decrying the scientisation of the policy process). However, as has already been discussed, it is the drive for relevance (under a weak ecological modernisation) discourse that could be considered hegemonic. As such, it is calls for a more legitimate and accountable science which represent the primary challenge both to science as an institution and to its relationship with this dominant discourse.

It is clear that while powerful, the dominant ecological modernisation discourse governing bioenergy policy and the positivism governing scientific practice are not so hegemonic as to suppress all challenges. Degrees of agency are evident in the form of competing discourses that have impacted upon practices in both.

Nevertheless, whilst competing discourses are evident, it is clear that certain practices within both science and bioenergy policy act to subjugate alternative understandings. As discusses in the previous chapter, the particular conception of relevance within science policy has had a significant impact upon bioenergy science through the creation of research themes reflecting particular policy objectives (e.g. least cost climate change mitigation). It is also clear that practices such as interdisciplinarity have also acted to constrain alternative agendas associated with particular social science disciplines.

Although superficial focused on climate change, it is obvious that there are many drivers for bioenergy, many of which are linked to a broader neoliberal agenda. While biofuels have been promoted under a rationale of climate change mitigation, in response to the challenges over the cost of biofuels as a decarbonisation strategy, it appears that there is at least some effort going into reframing the debate over biofuels around energy security. This strategy has also shown to be important in maintaining support for nuclear power. For example, Scrace and Ockwell (2009) show that while in 2003 renewable energy was framed as serving economic growth, in 2006 it is framed as an incomplete solution to a potential energy gap. They claim that the 2006 review was an opportunistic attempt to legitimise renewed government support for investment in nuclear power. In this new security framing nuclear power fares much better, given its relatively high costs. They also conclude that the framing of the debate around climate change and energy security allows the knowledge claims of the nuclear industry and some scientist to be privileged over others. The strategic use of the sustainability rhetoric in energy policy to conceal multiple agendas is another reason why it is important for science to engage with such concepts in a reflexive manner. Within the research initiatives studied, the vast majority saw climate change as the primary driver (and many as the only driver) of bioenergy.

8.3.3 Structuring science

While this thesis has focused much on the way that dominant discourses within both policy and science have constrained competing discursive positions, these

alternative positions have not been completely subjugated. For example, while biofuel policy in the UK has not significantly changed direction, it has been slowed. Also within UK research-council science, the existence of the RELU programme potentially represents a radical approach to interdisciplinarity. Despite its explicit focus on energy crops and land-use in the UK, in its organisation, RELU-Biomass is very different to the energy programme initiatives. The primary differences being that interdiscplinarity and a substantive interactivity form the core of the project. While social sciences traditionally play an 'end of pipe' role in interdisciplinary endeavours, within RELU-Biomass public engagement formed the central theme of the project.

Although engagement was limited to a fairly specific agenda and did not challenge the current policy framings around bioenergy, the central role given over to disciplines involved with public engagement is reflected in RELU-Biomass being the only project in which there were project wide discussions over the meaning of sustainability and what it meant for the operation of the project. Despite the project wide, substantive approach to public engagement however, it is evident that tensions over the normative aims of the project still existed; even if these tensions seemed less pronounced. Whether this reflects the funding structure of the RELU programme is unclear. For example, while Evans and Marvin (2006) make the case that the fundamental obstacle to interdisciplinary research is the knowledge practices of individual disciplines, Lowe and Phillipson (2009) disagree, maintaining that funding structure are more important barriers than these paradigmic aspects of research. One RELU member suggested that while interdisciplinarity may seem to marginalise certain debate, that the impacts of it might be more subtle (quote 160).

> *160. a lot of social science research, to be honest, is political action by other means and the state sort of tolerates it. But it's quite ideologically driven and to a certain extent interdisciplinary research begins to marginalise that sort of agonised, ideologised debate because it is often very problem driven. Now that makes it sound as if it would be deeply conservative rather than radical, in terms of it's aspirations. But what it does is, in a quieter way, begins to radicalise the scientific and technological projects. It introduces a greater sense of different ways of doing science and technology, so particularly gets*

scientists and technologists thinking about the context of their work, beginning to think in a much more reflexive way about their work. Begins to humanise the science and technology

Conclusion

It is clear that sustainability as a concept plays an important role in the politics of bioenergy. Chapter 4 showed how sustainability has been used to legitimate what many would consider a fundamentally unsustainable status quo. The use of the sustainable development storyline can thus be seen to have been used in energy policy in strategically ambiguous ways (Eisenberg, 1984), to both legitimate certain interests and potentially to de-radicalise alternative discourses. However, while it is possible that less powerful positions may be de-radicalised under such a meta-discourse (it is assumed by many that the concept of sustainability in this way led to the de-radicalisation of the environmental movement in general), this ambiguity may also present the opportunity for new conceptions and different representations of sustainability to express themselves. That is, it may be harder for discursive closure around such a historically contested and inherently political concept. This is most obvious in the way it was used by researchers in their funding applications. While framed in the same language, all of the research projects represent a slightly different conception of sustainability than represented by the dominant energy policy discourse. While reinforcing much of the dominant discourse, the framing of bioenergy in this way may also have opened the door for inclusion of some of the more critical aspects of these projects and the potential for more subtle influence.

Despite this, it is evident that a perceived separation of science and politics, and a linear view of scientific policy making are still pervasive within bioenergy research, and may constrain competing discourses. This view of the relationship between science and policy is perceived as important for maintaining authority in both science and politics. However, not only does this view of scientific policy making act to reproduce relatively narrow interests, it

also acts to legitimize a general scientization of such debates (Sarawitz, 2004). Decarbonising our energy supply has become dislocated from its underlying (disputed) ethical and moral rationales. As such it has seemingly become an end in its own right; reducing GHG emissions has become an inherently good thing to do (Sarawitz, 2004). Bringing the value disputes embodied in and concealed by science into the political arena can thus be assumed as necessary for successful democratic action. The controversy over biofuels (and increasingly bioenergy in general) will not be resolved through technical and scientific debate, and in many ways it seems likely that, by obscuring the value disputes at the heart of the debate, the production of more science may actually be making the controversy worse. While making complex value disputed controversies worse, technical debates of this kind also vitiate the will to act. Claims to resolve uncertainty through the production of more science acts to squeeze out democratic debate on the underlying reasons for addressing issues such as climate change.

While there is an abundant literature concerning how science needs to change to more fully address the challenges of sustainable development, a common feature is the need for a science that is more reflexive as to whose interests it is serving. As such, the most basic feature of a science for sustainability is a science that engages proactively with the normative goals of sustainable development. Only by engaging with and being reflexive to the values embodied within the production of scientific knowledge, will politics be forced to emerge from behind its façade of scientific controversy. Appropriate decisions about scientific priorities can emerge, and science can be liberated to serve society only when science engages reflexively with the role scientific knowledge plays in modern political controversies. It seems trite to suggest that any social activity aiming to contribute to sustainable development should need to engage deeply and reflexively with the broader normative dimensions of such a politically contested concept. To whatever degree one views scientific knowledge as inherently political, it is hard to deny the political use of science in modern environmental controversies. The issue of legitimacy in science is unlikely to be resolved by denying, or trying to escape its own politicisation. Rather, there would seem to be strong argument for those involved in science

to instead recognise and engage with these political aspects of science, to the greater benefit of both science and society.

There are various obvious difficulties in regard to making research more interactive. Not least among these is the resources needed for such engagement (Woolgar, 2000). Equally there are questions over how to define accountability and legitimacy, and how to compare and reward science driven by these objectives. This issue is linked to the very problem of identifying appropriate 'user groups', 'publics'. A perennial danger, whatever the intentions of participation, is that given that it takes capacity to engage with research, those that have this capacity are more likely to gain at the expense of less powerful or diffuse users (Shove, 1997). Despite the uncertainty over how specific practices need to change in order to better equip science for sustainability, it has been suggested that a more influential role for research might involve engaging with the broader aspects of an issue and challenging the way it has been framed in decision-making communities (Scott, 2004).

While this thesis makes no claims as to the impact of projects on the future of bioenergy, it does highlight the apparent lack of reflexivity concerning the social function of science involved in forwarding a sustainable development agenda. The broad approach to analysis engendered by discourse analysis has allowed the science to be set within its political context. Taking a broad analysis of these projects in the context of the bioenergy debate, it seems obvious that the majority of this research into bioenergy may not reflect current public concerns. This is reinforced by the observed explicit opposition to such reflexivity found within the scientific and engineering communities. The statement that this thesis wants to make is not about the projects individually, but rather about research of this kind in general and the importance of taking a broad, social theoretically grounded approach to analysis of sustainability in action. While the project websites did reflect some opinion within the projects, in many ways they reflected an extreme version of consensus, particularly in the case of the UKERC website. While this simplified, positive approach may reflect a certain conception of the public as misinformed and 'dangerous' in terms of their perceived irrationality when presented with complex information, given the very

public nature of the debate and potential issues with bioenergy, it is proposed that this strategy may well backfire. Much of the opposition to biofuels, is rooted in an engrained lack of trust of the institutions governing its development. It is therefore suggested that denying the concerns over bioenergy is unlikely to build the trust needed to engender widespread support for bioenergy.

Given the widespread contention over biofuels and issues of land-use, it is suggested that while more research that directly addresses the political nature of bioenergy is needed, this type of research should play a more 'up-front' role. If the science and engineering communities are serious about contributing to sustainability, they need to be more reflexive in their engagement with sustainability as a concept. In this respect, it is suggested that rather than being a 'bolt on', the more fitting place for critical sociological research is in driving the agendas of such research, rather than managing their impacts. Science and engineering are vital drivers of the transition to a more sustainable development. However, if science and engineering are to respond to the challenges of sustainability they need to fully engage with its normative values as well as its political contestations, questioning both what their impacts might be and whose interests they are serving.

Chapter 9 Conclusion

The primary aim of this thesis was to produce a critical exploration of the ways in which research-council funded bioenergy science had engaged with the politics of bioenergy sustainability. In approaching this aim, the thesis posed three specific questions:

1. How does UK energy policy discursively construct bioenergy, and how are these constructions challenged?

2. How have research-council funded bioenergy projects engaged with the wider discursive struggle over the sustainability of bioenergy, in terms of the constructions that they (re)produce and in the way they practice their research (in terms of content, aims and organisation)?

3. How have the discursive commitments of scientists been reproduced or constrained within the respective project?

To answer these questions this thesis took a discourse analysis approach, and focused on four research-council funded initiatives involved in carrying out research into bioenergy in the context of sustainable development. At the time, these initiatives represented the vast majority of interdisciplinary research into the sustainability of bioenergy. In exploring the ways in which these projects engaged with the question of bioenergy sustainability, the thesis drew on a particular tradition of discourse-analysis. Discourse in this thesis is imagined as consisting of both language and practice, and central to the mediation of power in society (Hajer, 1995). Viewing discourse as the engine of social change, this thesis is based on the assumption that not only does it matter how bioenergy sustainability is "talked about", but it also matters how this is reflected in certain social practices. Being involved with discourse-analysis, this thesis is explicitly concerned with the normative aim of 'unearthing' and making apparent the excise of power, and the asymmetry of power relations in the debate over the sustainability (and hence desirability) of bioenergy. As well as drawing on Dryzek's (1997) typology of environmental discourses, this thesis also draws on

work in STS, and in particular the identification of different rationales/discourses underpinning approaches to interdisciplinarity and interactivity within science (Fiorino, 1989; Stirling, 2004).

Bioenergy represents a variety of technologies, and is being developed and deployed rapidly in the UK as well as in a number of other countries across the globe. While developed primarily in the context of energy policy and climate change mitigation, unlike many other energy technologies, the land-use aspects of bioenergy engenders a number of other environmental and social considerations, and renders bioenergy amenable to a number of different problem framings. The rapid development (technological and regulatory) of bioenergy and in particular biofuels (at both European and domestic level), has led to a very public debate over the sustainability and desirability of certain technologies and practices.

Whilst promoted as sustainable technologies, bioenergy and biofuels particularly, have the potential to cause serious environmental and social harm. These impacts are also likely to be felt disproportionately by certain groups and peoples around the world. Bioenergy development thus raises many important moral, scientific and political issues. These issues form the basis of the debate over the sustainability of bioenergy. Sustainable development is now the dominant paradigm of development in the western world, and as such, the development of bioenergy as with other new technologies, is explicitly framed in these terms. Despite being contested, sustainable development and sustainability are not empty terms, but rather engender explicit engagement with the primary goals of environmental protection, social equity, and human development. In challenging the fundamentally unsustainability of traditional development, the concept is also politically radical.

In our quest for more sustainable patterns of development, science and technology are increasingly seen as essential components of this transition. However, recognising the role played in current sustainability issues, it is generally believed that science needs ‘reorientating’ to better reflect the underlying values of sustainable development (e.g. Kates *et al.*, 2001). To this

end there are a number of prescriptions for a more sustainable science. While these prescriptions differ in their underlying rationales for change, a common feature is the need for a science that is more reflective of a broader social interest.

9.1 The main findings of this thesis

This thesis makes a number of insights, that fall in to three broad areas. The first of these relates to the way that bioenergy sustainability is conceptualised under the dominant discourse represented by energy policy, and the way that this position is challenged. The second relates to the engagement of the projects with the debate over the sustainability of bioenergy. And, the third concerns the implications of this engagement. These findings are now reiterated under the three main headings below.

9.1.1 The politics of a sustainable bioenergy

Despite being framed in the language of sustainable development, there appears little evidence that the dominant energy policy discourse engages with what many would regard as the defining principles of sustainable development (namely, global social equity, environmental protection, and human development). Rather the discourse is best characterised as an attempt to implement something like a weak version of ecological modernisation (Dryzek, 1997). Under this discourse, bioenergy in all of its forms is articulated as a fundamentally sustainable technology. Biofuels have arguably received the most support of all bioenergy technologies, and while seemingly not congruous with the primary goals of least cost decarbonisation, biofuels are supported by recourse to a number of storylines and assumptions. Although promoted primarily under a rationale of decarbonisation, it is obvious that there are a number of other political drivers of biofuels.

Despite the very public backlash against biofuels, the UK has stayed vocally committed to both the technology as well as the prospect of raising the biofuels target to 10% by 2020. It has also consistently downplayed the potential impacts of the technology, with little credence given to claims over the impacts of international biomass production. While climate change and energy policy agendas have apparently converged with little conflict, it is arguable that this has been possible only so far as decarbonisation has been articulated as congruous with the primary energy policy goals of economic growth and energy security. It is therefore maybe unsurprising that the wider sustainability concerns of bioenergy are given little credence under this discourse. It is also clear that while the international sourcing of biomass for biofuel production may represent the primary concern of anti-biofuel positions, that this might be in direct conflict with the underlying neoliberal agenda, including a renewed emphasis placed on energy security in the 2007 energy white paper, which explicitly recognises the security benefits of being able to source biomass from a variety of regions. More than a rhetorical device, the UK Governments science-based policy approach is also a complicated policy practice. The scientisation of bioenergy policy has manifested in quasi-independent exercises such as the Gallagher review into the indirect impacts of bioenergy (RFA, 2008), and in environmental policy more broadly, in institutions such as the WTO. The institutionalisation of sustainability standards has acted to focus the debate on GHG balances, and replaced potential political action over ILUCs with further programmes of research aimed at reducing uncertainty in these areas.

While initially there was widespread support for bioenergy under a storyline of sustainability, support for biofuels is now very polarised. Within the very public debate over the sustainability of biofuels, two loose discourse coalitions are recognisable, split fundamentally over the existence of a biofuels target. The ‘pro-biofuel coalition’ is highly optimistic, technologically and in terms of political efficacy, drawing heavily on storylines of progress and pragmatism, and relying on science as the arbitrator of sustainability. Conversely, while often utilising scientific tropes in argumentation, much of the anti-biofuels discourse is rooted in a more precautionary approach to technological progress, utilising moral

arguments that foreground issues of responsibility, equity and a broader conceptualisation of the environment and its fragility. Rejection of biofuel technology stems in many cases not from a rejection of the technology *per se*, but from a distrust of the motives of the powerful corporate and governmental actors controlling the sector. There are two main challenges to the conception of bioenergy under the dominant discourse. The first of these involves the perceived over emphasis on carbon balances and economics as the primary metrics against which bioenergy sustainability should be measured. The second is more subtle and involves a rejection of the framing of bioenergy sustainability as a scientific and technical problem.

9.1.2 Characterising research into bioenergy sustainability

Whilst the initiatives explored in this thesis varied in their aims and approaches, it was nevertheless possible to draw some generalisations. The first of these was a general focus on the development of a UK bioenergy sector under an umbrella of least-cost-decarbonisation, and an associated lack of research into the international dimensions of bioenergy production (outside of a resource supply perspective). The second generalisation was the very positive and optimistic way in which bioenergy was constructed in communication with non-academics. It was also clear that while framed in the language of sustainable development, in many cases these concepts were used rhetorically. Used in a variety of contexts, sustainability was predominantly used as synonymous with carbon abatement and renewability. The caveat here would be the somewhat greater attention given to the concept within the RELU-Biomass project.

Despite varying views on bioenergy within the projects, the majority of the discourse over bioenergy could be regarded as what Dryzek (1997) would consider ‘administrative rationalist’ or weak ‘sustainable development’ in style. This discourse is optimistic as to the potential for humans to manage the environment, and extremely hierarchical in its conception of the social order. As such, it can be seen as being associated with very prescriptive accounts of the potential for bioenergy. Discussions over bioenergy were generally framed in

the language of technical and regulatory potential, rather than risk and precaution. Under this administrative discourse, it is the government that is the primary actor in sustainability and it is the function of science to provide evidence for rational decision making at this level. Policy-making in this way is seen as linear. Within this hierarchical structure, the role of science is clearly defined as the provider of evidence to assist in the rational management of bioenergy in the service of a clearly defined public interest. Sustainability, as with any other issue is amenable to resolution through clearly defined meritocratic structures. The political nature of bioenergy is thus not recognised, and this discourse denies the existence of politics of any sort.

9.1.3 Reinforcing discourses: Practices structuring science

Despite individuals within the projects holding differing views on bioenergy, as well as promoting bioenergy and focusing on least-cost decarbonisation, the projects also reproduced many of the assumptions and rhetorical devices underpinning the dominant discourse on their websites. This reinforcement of the dominant ecological modernistic discourse has some explanation in the practices associated with this discourse. Just as scientific policy making can be viewed as a form of practice structuring bioenergy politics and energy policy outcomes, so it can also be seen to influence research-council funded science.

The most obvious impact of scientific policy making and its increasing demand for relevance, is the funding of research through strategically managed programmes of research. The funding of bioenergy research almost exclusively through a programme of research (the energy programme) that draws its aims explicitly from energy policy goes someway to explaining the narrow conceptualisation of sustainability within the projects. It also goes someway to explaining the broader conceptualisation of sustainability within the RELU funded project. While funding structures may have influenced the commissioning of research, the hegemony of relevance has also had more diffuse impacts. It thus appears that pressures of relevance have shaped the content of the projects, in focusing them on ‘safe’ topics and excluding more

'risky' research on biofuels. In the case of bioenergy research, competitive pressures have had an impact in terms of limiting the interaction between the different initiatives.

9.1.4 The separation of science and policy

Although more focussed on visions of idealised bioenergy futures, in its technological optimism much of the discourse represented in the projects appeared to resonate with the ecological modernisation discourse of energy policy. It appeared that the dominant storyline of 'realising the potential' of bioenergy and the scientific policy approach to sustainability resonated with individuals in that they were viewed as apolitical objectives. It is thus argued that the described commitment to administrative rationalism within the projects appeared to reflect a very positivistic view of science. While individuals made recourse to many different discourse types, discussions over science and the role of science were strongly administrative.

Just as the ecological modernising tendencies of energy policy rely heavily on the existence of an 'objective' and 'sound' science with which to legitimise the enactment of evidence-based policy making, so the administrative discourse dominating science requires this separation to maintain its own authority. This positivistic/administrative discourse underpinning much bioenergy science rendered reflexivity as to the political goals and 'framing' of bioenergy irrelevant. Both are invested in the maintenance of a very linear view of scientific policy making. Both discourses also have similar conceptions of the public, primarily as consumers and in need of education about the benefits of bioenergy, and notions of technological progress. These similarities appear to have been reinforced to some degree by the rapid polarisation of the debate over biofuels.

It was evident that the primary tensions within the projects centred around those social science/sociological aspects that were explicitly engaged in more broadly conceptualising sustainability within the projects. Apart from RELU-Biomass, all of these aspects of the projects could be considered to some degree 'add-ons'.

The tensions existing between the sociological and other aspects of the projects appeared to reflect deep divisions in opinion over the role of science in society and the nature of expertise. These tensions also reflected contrasting commitments to the rationale for interaction of the projects with wider society. Thus, although a few individuals saw this interaction as necessary for normative and substantive reasons, the rationale for the majority of individuals was instrumental. While to some extent these differing discursive commitments managed to co-exist within the projects, it was also evident that the dominant commitment to instrumentalism also impacted upon the expression of these other interests. While practices such as interdisciplinarity and interaction have the potential to democratise science and make science more socially accountable, it is obvious that they can also act to subjugate alternative interests.

9.2 Science and sustainability

It is clear that the current debate over biofuels bears many resemblances to previous and in many cases ongoing public controversies over other technologies such as GM and nuclear power. The 'scientisation' of technological risk is evident again in the debate over biofuels, as is the cause of concern; namely the perceived motivations of government and industry, and the feasibility and desirability of comprehensively managing the environment. How then is science to contribute to a more sustainable development? Despite the tensions between the different prescriptions for a science for sustainability, all recognise the current hegemony of (narrowly defined) relevance and the impact that this has on wider aspects of legitimacy. They are all therefore concerned with the need for a science, or knowledge system that is more aligned with the interests of a broader set of social interests. Sustainability science, citizen science, post-normal science and all of the other proscriptions for a more socially and environmentally considerate science are not rationales that apply only to a certain fields, they are proscriptions for any science that is involved explicitly or implicitly in socially and environmentally contentious issues.

If science is to be liberated to contribute to a more sustainable future, then the very least it must do is engage seriously with the politics of sustainable development and recognise that dominant discourses may employ the rhetoric of sustainable development in strategically ambiguous ways to both legitimate incumbent interests and potentially to de-radicalise alternative discourses. Further more, rather than trying to blindly escape their own politicisation, it is argued that scientists must recognise the role played by science in modern socio-environmental controversies. This also involves more reflexive engagement with the necessarily provisional nature of scientific research and the non-linearity of scientific policy making. To challenge rather than reinstitute the separation of science and politics should be seen as a vital step towards a more socially accountable and reflexive scientisation (Beck, 1992) of environmental policy.

Given that the research explored in this thesis could not be considered regulatory, its impacts on specific policy are always going to be diffuse (one on the rationales for taking a discourse-analysis approach). While this thesis makes no claims as to the impact of the projects on the future of bioenergy, by taking a broad analysis of the bioenergy debate it does highlight the fact that at the very least, bioenergy research may not be reflecting current public concerns. This is perhaps reinforced by the observed explicit opposition to such reflexivity found within the scientific and engineering communities. Having said this, the statement that this thesis wants to make is not about the projects individually, but rather about research of this kind in general and the importance of taking a broad, social theoretically grounded approach to analysis of sustainability in action.

Given the widespread contention over biofuels and issues of land-use, it is suggested that more research that directly addresses the political dimensions of bioenergy is needed. Also, if the science and engineering communities are serious about contributing to sustainability, they need to be more reflexive in their engagement with sustainability as a concept. In this respect, it is suggested that rather than being a ‘bolt on’, the more fitting place for critical sociological research is in driving the agendas of such research, rather than

managing their impacts. Science and engineering are vital drivers of the transition to a more sustainable development. However, if science and engineering are to respond to the challenges of sustainability they need to fully engage with the normative values of sustainability, questioning both what their impacts might be and whose interests they are promoting.

9.3 Reservations and further research

While this thesis can be considered successful in terms of addressing its primary aims, there are recognised limitations to the study. The use of a discourse analysis approach can be viewed as an extremely useful way of exploring the nuances of a debate of this nature. However, there were recognised limits to the usefulness of the typology used. These limits were most apparent in the characterisation of individual narratives on bioenergy, which given the interviewees expertise, were often highly considered and caveated. While this thesis has provided insight into the way that sustainability is conceptualised within research-council funded bioenergy science, the impacts of this, while indicative are not obvious. Despite the importance of the websites in representing the primary way that the projects interact with non-academics and decision-makers, it is also evident that a lot of communication happens through individual associations, and therefore not directly in the context of the relevant project. From this point of view, a more institutional approach to exploring the interactions between science and politics in particular might complement such discursive analysis. One of the issues that the author of this thesis would have liked to explore further was the relationship between the projects and their funding bodies. However, while this thesis intended to more fully explore this relationship, given the difficulty in getting research-council staff to engage in interview, it was not possible.

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Appenix 1 Science policy in the UK

In the UK, overall responsibility for the Government's science policy sits with the Secretary of State for Trade and Industry. Research in the UK is funded by several sources, including government, industry and various charities. Whilst the Department for Innovation, Universities and Skills (DIUS) represent the largest benefactor of the UK's science budget, a number of other executive agencies and non-departmental bodies also receive funds. The main way in which the Government funds research is via the 'dual support system', in which the Research Councils support specific research programmes and projects, and the Funding Councils give block grant funding to support research infrastructure and enable institutions to undertake research of their own choosing. The primary recipients of Research Council and Funding Council funding are the public research institutes and Universities. As education is an area of responsibility for the devolved administrations, Scotland, Wales and Northern Ireland each have their own Higher Education Funding Councils, operating in a similar way to the Higher Education Funding Council for England. In the UK there are seven research councils, each primarily covering a different part of the research landscape. These are:

• The Arts and Humanities Research Council (AHRC)
• The Biotechnology and Biological Sciences Research Council (BBSRC)
• The Engineering and Physical Sciences Research Council (EPSRC)
• The Economic and Social Research Council (ESRC)
• The Medical Research Council (MRC)
• The Natural Environment Research Council (NERC)
• The Science and Technology Facilities Council (STFC)

Established by Royal charter, the councils are all autonomous, non-departmental public bodies. Research in the higher education sector is supported directly through the provision of research grants, fellowships and postgraduate studentships from these councils. Each research council is principally funded by the science budget from the Department for Innovation, Universities and Skills (DIUS), with additional commissions from government departments and agencies, industry and international organisations. The objectives of the Research Councils are defined in their Royal Charters. The Royal Charters follow a similar format for each council, and identify three specific objectives that can be summarised as:

- To promote high quality scientific and engineering research.
- To train skilled people, and to advance and disseminate knowledge and technology with the aim of meeting national needs of the economic competitiveness of the UK and the quality of life.
- To promote public understanding in science, engineering and technology.

Research is funded through specific programmes developed by the Research Councils in consultation with DIUS. Programmes can either be 'responsive' or 'targeted', and all rely on peer review to confirm that research proposals merit the funding requested. Whilst the research councils have traditionally operated unilaterally, the increasing demand for interdisciplinary knowledge (reflecting the current emphasis on knowledge transfer, commercialisation and end-user partnerships) means that more and more cross-council initiatives are being funded.

Since 2006, energy R&D in the UK has been overseen by a high level research and innovations forum, the UK Energy Research Partnership (UKERP). The UKERP is led by the Chief Scientific Advisor (OST) and brings together the key funders of energy research from government, industry, academia and other relevant parties. Research and development into renewable energy within the UK is split broadly between government departments and the research councils (EPSRC led). 'Blue sky' research is primarily supported through the Biotechnology and Biological Sciences Research Council (BBSRC) and the Engineering and Physical Sciences Research Council (EPSRC), whereas deployment programmes are primarily supported through the Department for the Environment, Food, and Rural Affairs (DEFRA), the Department for Business, Enterprise and Regulatory Reform (BERR, previously DTI) and the Department for Energy and Climate Change (DECC).

Established in 1999, bioenergy research is coordinated at government level by DEFRA's 'Bioenergy R&D Funders Forum' (BFF) which was established to effectively coordinate research in this area, as well as setting future research priorities. As well as a number of government departments, the BFF also includes the Environment Agency (EA), Forestry Commission (FC), EPSRC and BBSRC. Each member of the forum procures or funds research to meet its policy requirements and the forum provides a space for discussion in order to reduce duplication of research and exploit synergies. The involvement of its members in ERA-NET Bioenergy and the International Energy Agency (IEA) take account of international dimensions.

The BFF's activities are informed by the UKERP, which assesses the research needs for the whole range of energy technologies. The BFF's work is also supported by the UK Energy Research Council's (UKERC) 'bioenergy roadmap'; intended to identify gaps and priorities in renewable energy research (UKERC, 2006). The BFF's role is to provide a space for discussion as to how these identified needs are addressed. BBSRC's Bioenergy Review (BBSRC 2006) has also fed in to this work. The National Institute for Energy Technologies (NIET), announced in March 2006 is designed to augment the UKERP.

DEFRA initiated its energy crops R&D programme in 1994. The programme is managed by the Sustainable Farming and Food Sciences division and amounted to a spend of £0.9m in 2004/2005. The aims of the programme were reviewed in 2003, and are geared towards furthering the agronomy and pest control of miscanthus, willow and poplar, under an objective of doubling commercial bioenergy crop yields (DEFRA, 2003a). BERR is a major funder of bioenergy research toward the market end and operates through the New and

Renewable Energy (NRE) Technology Programme, managed by Future Energy Solutions (FES) as part of AEA Technology. The programme aims to support pre-competitive R&D to improve economic viability of new technologies. The total biomass project portfolio is in the region of £2.5m per annum, awarded through open calls for proposals. Bioenergy was also supported through its now closed, £66m Bioenergy Capital Grants Scheme (£36m of this was provided through The New Opportunities Fund). A further round of the scheme, focussing on biomass heat and CHP, was announced in April 2006. It will run for five years and will be worth some £10-15m in England over the two financial years to 31 March 2008. In 2006, a new £80m DTI Technology Innovation Programme was announced.

In respect of other bioenergy research funders, the Scottish Executive, DARD, EA and FC's contribution is relatively small. Of note however is the EA's development of the Biomass Environmental Assessment Tool (BEAT) software to aid agency staff in decision making on biomass projects. While it is difficult to assess commercial research activity, there are a number of industrial partners collaborating in the research-council led SUPERGEN Biomass, biofuels and energy crops consortium (see section 8.2.1) and UK Sustainable Hydrogen Energy Consortium (BP; BOC Group; Shell Global Solutions UK; Corus UK Ltd.; Tetronics Ltd.; Ilekia Technologies Ltd. Qinetiq; Johnson Mathey). The Towards a Sustainable Energy Economy-BIOSYS consortium is also developing close industrial links (see section 8.2.3).

Appendix 2. Project information

Table showing SUPEREGEN-Bioenergy workpackages

Phase 1	
Theme/work package	**Activity**
WP1 Techno-economic assessment	Technically analyse complete bio-energy process options
	Integrate components from other WPs, to optimise routes, and highlight areas to maximise performance and economics,
	Assess economic performance
	Assess life cycle performance
	Examine socio-economic factors, including social acceptability, land-use, landscape, transport, processing, emissions
	Carry out multi-criteria evaluation of technical, economic, environmental and social consequences of an agreed set of options (Case Studies), with stakeholder involvement.
WP2 Fuel specification & matching	Relate agronomic practices to biomass composition and characteristics,
	Evaluate fate of alkali metals in combustion, gasification and pyrolysis,
	Study effect of low lignin biomass on pyrolysis liquid composition and characteristics,
	Establish relationship between biomass quality, technology and product characteristics
	Calculate carbon balances for biomass
	Produce crops at large scale for testing
	Behaviour of metals in combustion and co-firing
	Develop screening methods for genotypes
	Evaluate grasses for ethanol and hydrogen (H2 consortium)
WP3 Thermal reactor modelling	Integrate CFD with particle modelling codes and reaction kinetics,
	Develop reaction pathways and mechanisms for each feed material and each conversion route, particularly relating to tar cracking and secondary reactions in all conversion processes,
	Derive improved process models of packed and fluid bed reactors and reaction systems,
	Derive co-firing and co-processing performance models,
	Predict deposit formation related to feed characteristics and reactor configuration,
	Study metals release during combustion.
WP4 Minimising engineering risk	Perform combustion trials on new feed materials with co-firing, blending and additives to control fouling,
	Critical review of the current status of gas cleaning technologies and specifications for fuels,
	Combustion, gasification and pyrolysis trials on new feed materials and blends with coal,
	Evaluate fouling potential,
	Derive RAMO models for combustion and gasification heat exchangers,

	Overall systems issues - efficiency and RAMO,
	Evaluate novel gas cleaning for gasification cycles,
	Derive monitoring and control systems for fast pyrolysis.
WP5 Co-firing and co-processing	Evaluate co-firing and co-processing of biomass and coal and study fate of alkali metals,
	Improve pyrolysis liquid quality by feed selection and process improvement,
	Develop and validate sub-models for the co-firing of coal-biomass blends and biomass-biomass blends,
	Derive performance models of fossil fuel combustion with supplementary bio-oil or producer gas
	Derive models for techno-economics, life cycle and social criteria analysis of co-firing and co-processing,
	Evaluate co-firing bio-oil in a coal fired boiler,
	Evaluate co-firing producer gas in a coal fired boiler,
WP6 Network	Establish a Network - *British Biomass and Bio-energy Forum*,
	Develop links with other researchers, companies, and organisations nationally and internationally,
	Organise open meetings, workshops and seminars for interaction and dissemination,
	Develop a database of active researchers and companies,
	Publish a newsletter and website,
	Promote the Consortium,
	Provide support and advice to policy and decision makers.

Phase 2	
Theme/work package	**Activity**
1. Resources	Pre-Harvest Feedstock Enhancement and Characterisation
	Markers for yield and conversion
	Biotechnology of Miscanthus and Willow
	Energy crop agronomy
	Biomass supply chains
	Potentials and impacts of imported biomass
2. Characterisation and pretreatment	Pre-harvest feedstock enhancement and characterisation
	Analytical and characterisation method development
	Markers for yield and conversion
	Waste preparation, processing and integration with biomass
	Fuel handling and preparation: Pelletisation
	Data interpretation and predictive capabilities
3. Thermal conversion	Biomass reaction mechanisms
	Implementation of biomass reaction model
	Fuel related engineering issues in biomass gasification
	Co-gasification of bio-refinery products
	Mass and heat transfer coefficients in pyrolysis vapour quenching
	Exploration of pyrolysis of unusual biomass residues and wastes
4. Power and heat	Development of advanced CFD based biomass combustion model
	Cofiring and co-utilisation of biomass and waste materials
	Biomass systems for domestic heating and district heating

5. **Transport fuels and biorefinery**	Hydrocarbon synthesis from syngas
	Bio-transport fuel production process analysis
	Biorefinery analysis and evaluation
6. **System analysis**	Resource assessment
	Systems analysis (technical, economic, environmental, social)
	Multicriteria assessment and deliberative engagement
	Pathways, policies and impacts
7. **Dissemination and collaboration**	Newsletter
	News bulletins
	Website
	Factsheets
	Bioenergy Research Forum
	Collaboration
	Financial management

Table Showing academic and non-academic partners involved in the SUPERGEN-Bioenergy consortium.

Phase	**Academic Partners**	**Non-academic partners**
1.	Aston University Cranfield University University of Leeds University of Manchester University of Sheffield Rothamsted Research Institute of Grassland and Environmental Research	Alstom E.ON UK plc Rural Generation Ltd
2. **Additional Partners as of 2007**	Imperial College London Forest Research Kings College London	AMEC BIFFA Waste Services Ltd. BICAL BP Biomass Engineering Ltd. Coppice Resources Ltd. RWE NPower

Table showing academic partners involved in UKERC phase 1.

Phase	Academic partners
1	Imperial College London Centre of Ecology and Hydrology Council of Central Laboratory of the Research Councils Edinburgh University Manchester University Oxford University Warwick University

Table showing research themes in TSEC-BIOSYS

Theme	Task
Theme1 Bioenergy demand and supply dynamics	1.1 Develop bioenergy scenarios
	1.2 Scenario analysis
	1.3 Conversion technology modelling
	1.4 International bioenergy trade-implications for UK
	Stakeholder engagement
Theme 2 Evolution of biomass supply	2.1 Crop improvement
	2.2 Productivity modelling
	2.3 GHG impacts of biomass production
	2.4 Environmental impacts of energy crop production
	2.5 Land use decisions
Theme 3 Sustainability analysis of bioenergy supply chains	3.1 Sustainability and MCDA framework
	3.2 GHG emissions assessment for alternative pathways
	3.3 Sustainability assessment of system
Theme 4 Total system performance	4.1 Recommend strategies, policies, regulations

Imperial College London (ICEPT, CPSE, Biology department) University of Surrey University of Southampton Oxford University Centre for Environment- was at UCL University of Glamorgan University of Birmingham University of Aberdeen Rothamsted research Centre for Ecololgy and Hydrology Institute for European Environmental Policy (IEEP) Scottish Agricultural College Forest Research Edinburgh Centre for Carbon Management

Box Showing Institutional partners involved in TSEC-BIOSYS

Appendix 3. The Interview schedule

Introduction by me: Thank for their time. Repeat e-mail reassurances as to confidentiality and anonymity. Explain the purpose of my research.

As part of my thesis, I am interested in the way bioenergy research engages with, and operationalises, notions of sustainability and sustainable development. When I talk about bioenergy during this interview, I am using it in a very broad sense to refer to the use of recently produced biological material for energy purposes. However, feel free to comment on any particular technology or process as you see appropriate.

1. **Introduction to research. I wonder if you could start by giving me an introduction to your research interests.**

    - Would you associate yourself with a particular academic discipline?

2. **Motivations. Why did you become involved in bioenergy research?**

    - Are these the same reasons for becoming involved in the ??? project?

3. **Project. Could you tell me a little bit about the ??? project and your research on it?**

    - What are the aims of the project?
    - How were the aims and objectives of the project decided?
    - Why do you think that this project funded?
    - What do you see the project achieving?/ How do you think the outputs will be used?
    - How are the outputs going to feed into policy making?
    - Since its inception, has the project changed at all?

4. **Interdisciplinarity. The ??? project describes itself as interdisciplinary/multidisciplinary. Could you explain what interdisciplinary research is?**

- Is it important that this type of research is interdisciplinary?
- Do you think that there are tensions between producing relevant science and good science?

5. **Interdisciplinarity on the project. What have been your experiences of interdisciplinarity on the project?**

    - Has the need for interdisciplinarity influenced your research or the questions you ask?
    - How much you have interacted with other members of the project from other disciplines?
    - Has there been any resistance to interdisciplinarity on the project?

6. **Interactivity. Do you interact with non-academics as part of your research?**

    - Who do you interacting with and how?
    - In your view are these the right people to be interacting with?
    - What role does this interaction fulful?
    - Why is it important/ not important?

7. **Interactivity on the project. The ??? project involves specific stakeholder engagement activities. Could you describe these and comment on the relevance of these activities?**

    - Is the project is engaging the right people in the right way?
    - Who would you consider as a stakeholder in this type of research?
    - How much time have you spent interacting with non-academics on this project? How does this compare with your colleagues?

8. **Broader public. What are your views on the relevance of interacting with a broader 'general' public in this type of research?**

    - How should they be interacted with?
    - Most of my knowledge of the ??? project has come from the website. What purpose does the web-site fulfil?
    - What are your views on the content and style of the web-site?

9. **Bioenergy. Moving on to bioenergy. I wonder if you could start fairly broadly, with your opinions on it as a technology choice.**

    - How you would like to see bioenergy develop as a technology. Globally and in the UK, Biomass and Biofuel/ what sort of scale
    - What do you think might be the main implications of a large scale development of bioenergy in the UK
    - And globally

10. **Policy. In your opinion, what are the primary drivers behind development and deployment of bioenergy technology in the UK?**

    - What are your opinions of current UK and EU policies concerning bioenergy?

11. **Research**. **What are the major research questions facing bioenergy?**

12. **Media. What is your opinion of the way the media have reported on bioenergy?**

    - Why has there been the reaction there has been over bioenergy?

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13. **Sustainable development. I'd like to know what the terms sustainable development and sustainability mean to you.**

- With regard to SD, what is it that is to be sustained?
- Are they useful concepts?
- Do you think your conception differs from other peoples?

14. **The project and SD.**

TSEC/UKERC: The project is framed in the context of a 'Sustainable Energy Economy'
SUPERGEN: The project is framed in the context of a Sustainable Power Generation and Supply.

- How do you expect the project to contribute to SD?
- How did the project decide on its definition of 'sustainability'?
- What is the project aiming to sustain? What are the primary characteristics of a ???
- (SUPERGEN) Do you think there are any tensions between the technology enabling and regulatory aspects of the project?

15. **Bioenergy and SD. How is bioenergy likely to contribute to a more sustainable development?**

- Bioenergy is often described as a 'sustainable technology'. What do you think this means?
- I wonder if you could comment on the development of effective sustainability criteria for the growing and trading of energy-crops and their products?
- Is there a need to interact with the public on more fundamental questions over the use of bioenergy?

16. **Science. What role should science or research in general, play in sustainable development?**

- What needs to change to ensure research contributes more effectively to sustainable development objectives?
- Do you think there is a problem of trust between the public and science/research?
- What ethical responsibilities do you think that you have as a researcher engaged in this type of research?
- There have been many calls for a ‘democratisation of science’ or a greater social accountability for science; do you think that this is a legitimate or useful position?

17. Is there anything else you would like to add?

Appendix 4. Reflexivity

It is important when engaged in this sort of research to be reflexive about ones own aims, opinions and discursive affinities as they necessarily impinge upon the interpretive nature of the analysis. During the writing of this thesis I have developed strong opinions on bioenergy. I am of the view that bioenergy represents a great potential, in not only helping to transform our current energy system into one that is both less carbon intensive and secure, but also in going some way towards decentralising our energy system, connecting people with where their energy comes from, increasing employment, and also to an extent improving a number of other environmental metrics. However, I am also concerned that bioenergy also represents a potentially serious threat to certain environments and certain sections of the global community and that managing such impacts is probably not possible or in many instances desirable. Given the vast number of bioenergy pathways and the likely context dependant impacts of bioenergy, I am of the view that many of the potential benefits of bioenergy are unlikely to be realised through the kinds of market based support mechanisms and criteria based regulation that are currently proposed. Thus while I am keen to see bioenergy develop particularly in the heat and electricity sectors I am concerned that this needs to happen under a much broader conception of the public good than currently is the case. While I am not against biofuels, I am much more concerned about the impacts of international trade in bioresources and generally regard the conditions of 'free trade' under which such trade is currently conducted as likely to entail unforeseen impacts.

I am of the opinion that, while much of made of the potential social benefits of bioenergy trade internationally, if this is not being the primary rationale for bioenergy development it is unlikely to result in such benefits. It is also my opinion that in the case of biofuels policy, issues such as food security, long term environmental conservation and are being traded off against short term decarbonisation and fuel security. Thus the question that defines my support for bioenergy development is not so much its potential but the likely path of its development. While in this thesis I have tried to represent the various sides of the debate, in disagreeing with the current approach to bioenergy policy I thus find myself naturally more sympathetic to the arguments levied against the dominant discourse on bioenergy and in particular biofuels.

True to the normative aims of discourse analysis this project has attempted to empower those interests that are subjugated in the debate over the sustainability of bioenergy. While this task of identification is also always going to be subjective and influenced by the authors own interpretations, it is of the authors opinion that given the current and historical nature of the debate and current policies governing bioenergy, it is those interests attempting to frame bioenergy from a food security and generally broader perspective that are being systematically undermined given the current framing of the debate. Whether the impacts of an expanding bioenergy industry and associated trade in bioresources do have a positive or negative impact on the already largely disempowered voices of those living in developing countries is complicated and

unknown. However, while the role of bioenergy in international development may be, as claimed a driver of development, it is clear that this is not the primary rationale for the UK government or for those with commercial interests in bioenergy.